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## SELECTION FOR THE UNIVERSITIES

ONE of the outstanding features of the recent report of the University Grants Committee was its concern that, in the expansion of the universities of Britain, academic standards should be maintained or even improved, and that with the increased numbers of university graduates there should be no sacrifice in quality. This implies a greatly increased supply of freshmen of high quality; although there is little direct evidence on this point, there is no doubt that the schools could supply students well in excess of the present capacity of the universities.

This position is due in part to the numbers of older students in the universities whose training has been interrupted by national service. More than a third of the students at present in the universities of Britain are in receipt of grants under the Further Education and Training Scheme, or a total of more than 28,000 out of 77,000. Nevertheless, it cannot be assumed that, when this proportion of ex-servicemen diminishes, all the places will be available for younger undergraduates. The University Grants Committee considers that a limit should be put to the present overcrowding and consequent stress and strain, and its report implies that building up again even to the present numbers, still less the completion of the recommended expansion, should wait upon the recruitment and training of university staff and the physical expansion which will permit a normal university life and the maintenance of academic standards.

Although the Working Party on University Awards appointed by the Minister of Education in April 1948 was instructed to take account of the termination of the Further Education and Training Scheme, as well as of the increased numbers at the universities, and the probable abolition of the four-year grants for intending teachers, its report* makes surprisingly little reference to this question of quality and the maintenance of standards. Its recommendations will indeed, if accepted, sweep away many anomalies and irritations in the present system of awarding State and local scholarships. It is recognized that with the increased number of scholarships, it is unlikely that, as in the past up to 1947, State scholars will all be able to go to the universities of their choice; but the majority of the 'working party' considers they should be allowed to hold their scholarships at any university to which they may gain entry. The fundamental problem, however, is not the distribution of State scholars but the selection of students as a whole for admission to individual universities; and while the 'working party' advances a proposal for a university clearing house, on which Dr. W. W. Grave has reservations, it suggests that this larger question requires careful study.

The recommendations for raising the income-level above which a parent has to pay the whole of a State scholar's expenses, namely, from £1,500 to £2,000, and

* Ministry of Education. University Awards: the Report of the Working Party on University Awards appointed by the Minister of Education in April 1948. Pp. iv+26. (London: H.M. Stationery Office, 1948.) 9d. net.

for increased maintenance grants and allowance, will ease a 'means test' which at present bears heavily on middle-class families. The clarifying of the principles on which State awards are based should encourage the adoption of similar principles for local awards, and disarm some criticism of the continued predominance of the county awards. The abolition within the next three years of four-year grants to intending teachers is also recommended, in favour of provision for the degree course through the normal scholarship channels and continued finance of the students in the professional year by the Ministry.

The wider implications of these recommendations, however, need to be considered much more fully. In the first place, since the local authorities are urged "to extend their arrangements to include all eligible students accepted and recommended by universities who have reached the advanced standard in two subjects in the examination for the General Certificate of Education", all financial barriers to university education are in effect down. As the 'working party' itself puts it, to-day "Reasonable opportunity exists for the ablest students to reach the university irrespective of means". With the removal of anomalies and of limitations on those opportunities as recommended in this report, it is imperative that further thought should be given to the numerical aspect, the financial cost to the State and the question of selection.

It is with this last aspect that the universities are most vitally concerned, and although the 'working party' places squarely on the universities the responsibility for recommending awards both of open and of local scholarships—that is, of selection—it scarcely seems aware, except for Dr. Grave's dissenting note, of the administrative and other implications. The universities were inadequately represented on the 'working party'; and Dr. Grave himself, in emphasizing the speculative character of the estimated figure of 5,000 given in the report for the number of places which will continue for the present to be filled by students who do not need or do not qualify for awards from public funds, suggests that the university authorities should have been consulted before this forecast was published. The basis of this estimate is the assumption that the annual intake of students by the universities will continue at a level of 18,000 as against 12,000 before the War, and that of this total at least 4,000 will be suitable candidates for open or State awards. In normal times, a further 2,000 will consist of overseas students or others who are not eligible for awards from public funds. Assuming further the discontinuance of the four-year grants for intending teachers in accordance with its own recommendations, the 'working party' suggests a minimum of some 7,000 awards to be made through local education authorities. It is this figure which is challenged by Dr. Grave, who is clearly anxious that the pressing need for university graduates will not result in a lowering of standards for admission. As he rightly observes, once standards are lowered it is very difficult indeed to restore them.

The University Grants Committee, from its recent report, is clearly fully alive to this danger, and it is to be hoped that the Minister of Education will consult the universities very fully and satisfy himself and the universities that conditions detrimental to the maintenance of academic standards are not prolonged or even made permanent by the premature adoption of a scale of awards too high for present conditions. The University Grants Committee, moreover, has the backing of the Nuffield College statement, and both bodies are far more representative of university opinion in Britain than the 'working party', only three of whose seventeen members came from the universities. If the university authorities, in the present circumstances, are unable to recommend for awards as many candidates as the report contemplates, they will have too much informed opinion behind them fairly to be accused of placing unjustifiable obstacles in the way of deserving students.

It is to be hoped, therefore, that the Minister of Education will give his support first to the proposals for the physical expansion of the universities and the provision of staff and buildings on a scale which will put a speedy term to the present overcrowding, and he can well decide that the number of public awards for 1951 shall be rather lower than the 'working party' suggests without denying a chance to anyone of real ability. In the debate in the House of Commons on December 17, the Minister of Education, while making it clear that the report had not yet been accepted, indicated that it might be concluded that the earmarking of students for the teaching profession before they entered a university would be discontinued and that, along with the considerations advanced in the debate itself, he would take full account of the representations which might come to him from the universities.

The fact that, as Mr. Tomlinson disclosed, awards are still being made under the Further Education and Training Scheme at the rate of 400 a week to students who were called up before September 30, 1947, may postpone the need for decision for a little while; but it is well to be quite clear as to what is involved in the general agreement that no one should be barred by poverty alone from a university education. As the University Grants Committee points out in its report, when the great majority of students are subsidized, it may not be possible to stop short, subject to a means test, of subsidizing all; and in spite of the difficulty of defining what is meant by "benefit of a university education", it will be necessary to face an entirely new problem of selection.

The University Grants Committee starts with the assumption that the universities must not be deprived of effective choice of their own entrants, and in this it is clearly supported by the 'working party'. The Committee also recognizes that it is desirable to exclude one type of student whom the possession of means once enabled to secure admittance —the riotously living passman, sometimes of athletic promise, on whom the university as an agency of culture made small dent. There is equally the problem of identifying at the stage of entrance to the university the other type of student, who gains much from the university and whose usefulness to

the world is much enhanced by his stay there although he is not of outstanding intellectual ability. Even if, as the University Grants Committee appears disposed to agree, the removal of certain obstacles to access to the universities has eliminated also a measure of selection and lowered the average quality, the 'working party' may well be right in holding that only the adoption of its own recommendations regarding local scholarships will avoid a serious shortage of graduates for the various professions.

As to the basis of selection, the University Grants Committee merely observes that this is an unsolved problem to which the universities must now address themselves. Examination by itself will not suffice, nor will intelligence tests contribute much. Selection by interview and on the basis of reports from schools has the advantage of elasticity, but is open to the suspicion that the scales may be weighted unduly in favour of the socially eligible candidate of athletic prowess and pleasant manner and address. The 'working party' agrees that, for a considerable body of students of good academic capacity, school examinations by themselves cannot be a reliable test of ability. It suggests that the university should consider applications mainly on the grounds of the ability, attainments and inclinations of the applicants, their personality and character and the degree of competition from the other applicants. It believes, however, that more varied methods of selection are needed, and considers that the university authorities should be at liberty to interview a candidate and to apply for a suitable confidential report from the school.

Nor is this all. One other type of applicant at least, namely, those who, having left school at about fifteen and pursued their general education by part-time study, may prove to be well qualified for a university course. The 'working party' proposes that a certain number of such students should be selected on the ground of their record and intentions, supplemented by an appropriate written examination, and that the applicants should pass through a selection procedure similar in principle to that used by the Civil Service Selection Board. The final decision should rest not with the testing board but with a final selection board, constituted by the Ministry of Education, and on which the universities would be represented. This scheme would obviously remove the disadvantage at which such part-time students are placed in the ordinary written examination, and the 'working party' wisely suggests that the scheme should be tried at first on a very small scale. Dr. Grave objects to universities being asked to accept the recommendations of any final selection board, apparently basing his criticism on the Ninth Report from the Select Committee on Estimates (Session 1947–48), which discussed the Civil Service Selection Board (London: H.M. Stationery Office, 203, 205; 1948. 2*s*. net).

The selection of university students was one of the points made in the Fabian Society report, "Universities and the Future", in October 1947 (London: Fabian Publications, Ltd. Fabian Research Series, No. 120, pp. 33. 1*s*. net). Discussing the question, "Who Shall Graduate?", it is emphasized that a comprehensive scholarship system is also essential to ensure that, whether the universities expand or not, they recruit the best possible material and draw fully upon the country's reserve of talent. The report accepts more readily than the University Grants Committee the opinion of the Barlow Report that there is an ample reserve of intelligence in Britain to allow both doubling university numbers and at the same time raising academic standards. No opinion appeared to be expressed on this point at the discussion in Section L (Education) of the British Association meeting at Brighton on "Selection at the University Level" (see *Nature*, October 16, p. 626); but successive speakers recognized the difficulty of finding a solution for the problem, and also the need for an experimental approach.

This, however, is not all. Whatever method of selection may be devised, its adoption by the universities of Britain will involve heavy administrative responsibilities with which many of them are at present ill-staffed to cope. No doubt the University Grants Committee was not unmindful of this aspect in its observations on administration; but the magnitude of those responsibilities may well be a further reason for proceeding with caution. The points at issue, in fact, are essentially those of method and of timing, and the whole trend of the Minister of Education's remarks in the recent debate on university awards suggests that the recommendations of the 'working party' will not be implemented hastily or without due forethought and proper consultation of the universities, the weak representation of which on the 'working party' has rather diminished the weight of its recommendations. If that course is adopted, we should simultaneously be on the way to the thorough understanding between the universities and the schools which Mr. C. R. Morris rightly stressed at Brighton, and which Dr. J. F. Mountford had previously urged at the Home Universities Conference in September 1947.

## A FORGOTTEN HISTORY OF BOTANY

**Botanik der Gegenwart und Vorzeit in culturhistorischer Entwickelung**

Ein Beitrag zur Geschichte der abendländischen Völker. Von Karl F. W. Jessen. (Pallas, Vol. 1.) Pp. xxii + 495. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1948.) 6 dollars.

THIS volume is the first of a series of classical scientific works which the Chronica Botanica Company aims at bringing into fresh circulation. Jessen's book appeared in 1864, eleven years before the publication of the well-known "History of Botany" by Sachs; but, while a copy of the original or of the English translation of the latter is to be found in every botanical library, Jessen's book will be known to very few in Britain. In actual fact the two books supplement one another to a very con-

siderable degree, for, whereas Sachs' history begins with the early sixteenth century and gives little insight into the state of knowledge about plants among the ancients and during the Middle Ages, the first ten chapters of Jessen's book are devoted to these matters. After a brief consideration of the little that is known of plant studies among the early Indians, Egyptians and Babylonians, successive chapters deal with the state of botany among the Greeks and the Romans, during the early Christian era in Eastern and Western Europe and among the Arabs. A further four chapters dealing with the commencement of scientific studies in Western Europe brings the consideration to about the middle of the sixteenth century.

Jessen's book is, moreover, not a mere history of botany, but relates the progressive development of knowledge about plants to the general state of culture and of science as a whole at different periods. In fact, several of the earlier chapters contain as much information on the social history of the time as on the momentary state of botanical knowledge. It is this cultural approach that, as the editor remarks, renders Jessen's work unique. It carries with it also a different treatment of the subject-matter, since, in place of the separate consideration given to morphology and classification, anatomy and physiology by Sachs, Jessen in general discusses the state of the subject as a whole in each historical period.

The last ten of the twenty chapters into which the book is divided deal in the main with botanical history during the post-reformation period; in fact, one is devoted to the re-orientation of science which followed in the sixteenth and seventeenth centuries. The gradual development of systematic botany from its early beginnings to the middle of the nineteenth century is admirably traced and illustrated in tabular form at the end of the book, while other branches of botanical science receive a due share of attention, but are not as fully treated as in Sachs' history. The excellent chapters on agriculture and horticulture and on popular science and botany in the eighteenth and nineteenth centuries are part of the special framework of the book.

Jessen's history is very readable, and usually succeeds in avoiding long lists of names which tend to become tedious. Those who have contributed the lion's share in the advancement of botanical knowledge occupy the foreground, and due credit is given to the part played by the various European countries in this process. A list of botanical journeys and a good index add to the value of the work.

F. E. FRITSCH

## THEORY AND PRACTICE OF SUPERCHARGING

### Supercharging the Internal Combustion Engine

By Prof. E. T. Vincent. Pp. viii+315. (New York and London: McGraw-Hill Book Co., Inc., 1948.) 30*s*.

PROF. VINCENT has written an excellent book and is an enthusiastic exponent of his subject. The fundamentals of all aspects of supercharging are dealt with, and although the major part of the book is devoted to aircraft practice, there is much that is applicable to all forms of supercharged engines, including a chapter on the Diesel engine.

The author states in the preface that he is writing for "persons not directly connected with the theory or development of superchargers"; the needs of such persons are adequately catered for. Those interested only in air compressors will find that the chapters on these machines form a comprehensive text-book in themselves. The types of compressors described include reciprocating, rotary constant displacement, centrifugal and axial flow, and an account of the theory of each is given. An interesting chapter on surging in the centrifugal compressor is included. The subject of supercharging itself is dealt with fully, and there are chapters on the theory of the supercharged engine cycle, performance estimating, testing, engine-driven superchargers and turbo-chargers. The book is profusely illustrated with diagrams and photographs, and a number of useful charts of the properties of combustion gases are provided.

In an early chapter on thermodynamics the author shows a nice appreciation of what should properly be left out of a book of this type, where the emphasis is on applied rather than fundamental thermodynamics. In no less than three places the reader is advised to consult a text-book of thermodynamics for a more rigorous treatment of certain points, such as the statement that entropy and internal energy are functions of the state of a body. Obviously, full discussions of such questions are outside the scope of this book, and the author has been very wise in not allowing himself to become involved in them. It is a pity that more authors do not follow this example. On the other hand, difficult problems which are not usually found in text-books on thermodynamics are not shirked. Steady flow, for example, which is of fundamental importance to engineers and which is treated inadequately, if at all, in most text-books, is fully discussed.

E. G. STERLAND

## GEOLOGY OF THE LIZARD DISTRICT

### Memoirs of the Geological Survey of Great Britain

England and Wales. Explanation of Sheet 359: Geology of the Lizard and Meneage. By J. S. Flett and J. B. Hill. Second edition, by Sir John Smith Flett. Pp. xi+208+11 plates. (London: H.M. Stationery Office, 1946.) 7*s*. 6*d*. net.

THE Lizard district had long been famous as a field of geological research and controversy prior to the publication in 1912 of the Geological Survey Memoir on it, and on many of its petrological, structural and stratigraphical problems there was scarcely a general consensus of opinion. This second edition, by the late Sir John Flett, one of the original authors, reveals him in the full maturity of his scientific judgment and mental vigour. It has been entirely rewritten after a re-examination of the area that followed his retirement from the directorship of the Geological Survey in 1935. Many will visualize in these accounts of the cliffs and exposures "alongside the path leading from the hotel to the beach" that powerfully built figure with deliberate step and penetrating all-embracing eye.

The new edition of the one-inch geological map which appeared in 1934 contained substantial changes in the age-grouping of the sedimentary rocks, which

resulted from Prof. W. H. Lang's attribution of a Devonian age to the plants assiduously collected by Miss E. M. Lind Hendriks, and from Dr. C. J. Stubblefield's recognition of supposed Ordovician *Orthis* as a Devonian *Chonetes*. The significance of these changes is fully discussed. Regarding the age of the best-known Lizard rocks—the serpentines, gabbros and hornblende schists—Sir John ably presents the evidence; but generally reserves judgment.

The geological description is reduced from 263 pages in the first edition to 178 pages. In the introductory sections, geomorphology and soils receive considerably fuller treatment, and the interrelation of these with the underlying rocks is stressed throughout. These beneficial changes, the incorporation of new material, and the doubling of the number of text figures, especially maps, has, of course, involved the elimination of much detailed descriptive material. Lucid general descriptions and balanced critical discussion are preferred. The result is a combination of simplicity, clarity and scientific accuracy in a high degree. It may be that this work will be considered as representing what the eminent author in the fullness of his administrative and scientific experience regarded as desirable in an official memoir. Nevertheless, because of the elimination of much detailed description of important exposures, it might still be claimed that the old edition remains a valuable work of reference. A reservation should therefore be made that this effective compromise between a rather heavy, fully documented memoir and a much shorter explanatory guide does not necessarily represent a precedent of general applicability.

## THE ART OF GRAFTING PLANTS

### The Grafter's Handbook

By R. J. Garner. Pp. 223 + 24 plates. (London: Faber and Faber, Ltd., 1947.) 15*s*. net.

IN no branch of horticulture has so much ingenuity and manual dexterity been shown as in the art of grafting and budding. Over centuries, gardeners have taken pride in devising new methods by which two or more plants of different origin may be made to combine into a single entity, often for no reason other than to show their skill or originality, though sometimes to improve genuinely upon existing methods. Mr. R. J. Garner has probed deeply into the literature to discover as many of these ingenious devices as seemed to him worthy of preservation, and out of many hundreds he has put on record some eighty-odd methods of grafting, including a dozen or more of budding. All, or nearly all, are accompanied by unusually clear line drawings of the stages in each method, which help greatly to make plain the description in the text. If the book did nothing but bring together these scattered records and preserve them in collected form, it would have achieved something of historical value.

But the author is far more than a seeker into the past; he is a practical propagator of twenty years experience and a scientific man at the same time, and he has used his experience and his critical faculties to bring out the value of particular methods in particular cases and to show how a recondite or unusual means of manipulation may have a scientific justification in special circumstances. More than that, he has brought together the most up-to-date findings of research and the best traditional practices in the field of propagation as a whole, for he deals not only with the methods of grafting *per se*, but in the earlier chapters he also describes the methods of root-stock propagation and scion-wood preparation, which involves a discussion of many aspects of the problem.

The book is one which must be of the greatest value to the professional horticulturist, the amateur, and the student, all of whom will find in its pages not only guidance in technique but also clear exposition of underlying principles. A word of praise is due to the printers and publishers for the admirable type and format and, above all, for the clarity of reproduction of the author's own exceptional drawings and plates. Only too often photographs in a book of this type serve little useful purpose, other than presumably to increase the sales-value of the book; in this case every plate is a valuable illustration of some special point.

R. H. STOUGHTON

## THEORY OF THE STRENGTH OF METALS

### Report of a Conference on the Strength of Solids (1947)

Pp. 162. (London: Physical Society, 1948.)

THIS volume is a collection of papers given at a conference in Bristol in 1947 (see *Nature*, **160**, 696; 1948) together with a few additional papers. The solids dealt with are almost exclusively metals. The volume is divided into four parts of unequal length under the headings: "Creep and Plastic Flow" (70 pp.), "Grain Boundaries and Recrystallization" (47 pp.), "Precipitation" (20 pp.), and "Fracture" (4 pp.). The papers of the first part are concerned mainly with the deformation of metals associated with movement of dislocations. Dislocation theory has made good progress since the previous Bristol conference in 1939, and in the present volume many of the mechanical properties of metals are plausibly explained in terms of dislocations. The suggestion that solute atoms, such as carbon and nitrogen, may migrate to the neighbourhood of dislocations and hinder their movement gives an interesting interpretation of the yield phenomena in mild steel; and a first treatment of dislocation dynamics gives a plausible explanation of the multiplication of dislocations necessary to explain deformation by gliding. An interesting account is given of an electron microscope and diffraction investigation of slip in aluminium crystals. A notable omission is that a section, containing nine papers on creep and plastic flow and another of six papers on grain boundaries and recrystallization, should contain no papers on grain-boundary creep. The third section contains some good work on hardening of metals by the oxidizing *in situ* of solute atoms having a sufficient affinity for oxygen, and also a paper on the trapping of electrons in silver chloride, which raises the possibility of photographing dislocations.

In a volume entitled "The Strength of Solids", it is surprising that so little attention is given to fracture, and it leaves the impression that even the elements of a theory of the fracture of metals has yet to be given. Nevertheless, in view of recent progress in the study of the plastic properties of metals, we may look forward to a report on a not too distant conference on the strength of metals which does not belie its title.

C. GURNEY

# TRYPANOSOMIASIS IN AFRICA

IT is not always possible to contemplate with such pleasurable anticipation a series of Government publications such as those dealing with varied aspects of trypanosomiasis in Central Africa—a truly gigantic problem. This is discussed in the four important communications now published*. These reports form a series prepared for the Tsetse Fly and Trypanosomiasis Committee appointed by the Secretary of State for the Colonies and edited for publication by the staff of the Bureau of Hygiene and Tropical Diseases. It is right that it should be emphasized that this difficult task has been performed with that thoroughness and skill which are the hallmarks of this excellent institution. By so doing they have been embellished with a scientific *finesse* which will be appreciated all the world over.

The vastness of the trypanosomiasis problem which confronts the Colonial Governments and the Colonial Office to-day is emphasized in a popular appreciation. The havoc caused by tsetse flies in Nigeria, for example, extends over a country seven and a half times the size of England, so that one-fifth only of this huge territory is safe for men and cattle. On the Gold Coast, over the entire area of 91,840 square miles, these flies prevent the people from keeping the large-humped zebu cattle which should contribute enormously to their meat supply; thus they are compelled to rely upon their own native dwarf unproductive breed which is more resistant to trypanosomiasis. The third great West African Colony —Sierra Leone (27,500 square miles)—is quite over-run with tsetse, and endemic sleeping sickness in man occurs in one-tenth of the country, so that the same dire cattle problems present themselves and large numbers succumb to this disease. Though comparatively smaller, the whole of the Gambia (4,130 square miles) is infested with tsetse, while human sleeping sickness is sporadic; but nowhere can the larger and more economic cattle types be maintained.

One of the more drastic remedial measures which have been suggested is the extermination throughout 'fly country' of the numerous dog-faced baboons upon which these flies engorge themselves—a task more easily said than done.

In Uganda we learn of extensive pastoral areas which, some forty years ago, maintained flourishing herds of healthy cattle and now are clothed with impenetrable bush. In one epidemic, within three years, 200,000 natives, inhabitants of Busoga Province, were exterminated. To those who study the food problems of the world—and there are many at the present moment—it comes as a shock to learn that in all the East African Colonies there are said to be only some 14 million head of cattle to support more than 15 million people, and that this deplorable disproportion is to be ascribed to the tsetse fly alone.

The bionomics of some ten species of *Glossina* are dealt with in these reports. This is a field to which British entomologists have devoted special skilled attention. Each species has its own particular habitat and maintains its own peculiarities. Some can tolerate extreme ranges of humidity and temperature, whereas others avoid dry zones. Some thrive in the forest shade, others avoid it. Most of this information is contained in the exhaustive report by Dr. T. A. M. Nash—a document of some seventy-five pages, illustrated by sixteen topographical photographic plates, of outstanding excellence, and an appendix containing fifteen beautifully executed maps, which we understand are the most accurate and detailed ever published on this subject.

The largest of the West African cattle—the humped zebu—is the breed with the least resistance to trypanosomiasis, so that it cannot be kept in belts where *Glossina morsitans* abounds; therefore, bovine trypanosomiasis is most serious in northern Nigeria, where these cattle are dominant.

The riverine tsetses, *G. palpalis* and *G. tachinoides*, carry most of the sleeping sickness to man. The bulk of this human disease occurs in the savannah woodland zone and, broadly speaking, the disease appears to be absent from the main forest belt. Eradication of the tsetse with the means at present at disposal is a Herculean task, and it is not possible to go deeply into this subject. In short, it involves the clearing of vegetation against the tsetse, as each particular species preserves its own peculiar botanical association and only too often do these radical measures clash with the interests of the agricultural and forestry departments. This is gathered from Nash's own story of the Anchau Rural Development and Settlement Scheme. Here is unfolded a tale which should warm the heart of all true patriotic Britons. The Anchau district is in the Zaria province of northern Nigeria, where in 1934 it was found by Dr. N. E. W. Anderson that no less than one-third of the population had sleeping sickness and that the bulk of the area was infested by *G. tachinoides*. The Anchau settlement is the first large-scale attempt at rural development to be made in British West Africa, and marks the first occasion in that country in which the fly has been eradicated from a corridor 70 miles in length and covering an area of 712 square miles. The carrying through of this complete scheme has occupied some ten years and has entailed the co-operation of the Forestry, Veterinary and Geological Departments of the Nigerian Government. The scheme has now been completed at the comparatively cheap cost of £95,000 spent over a period of five years. That it has been well spent, and that it has afforded a demonstration of paternal Colonial Government in the best sense, a study of this fascinating account amply proves. In the Anchau district 3,700 people were moved out of 200 square miles of country, and eventually the whole population of 13,000 was settled into an area of 170 square miles.

We are given a glimpse of a primitive African town. It was indescribably filthy. Some 2,500 lived within a town wall which surrounded only 0·118 square mile, giving a population density rate of 21,200 to the square mile. On the weekly market days, about three thousand additional visitors would crowd into it, constituting a seething mob, all coughing, sneezing and spitting, owing to the peppers on sale in the tumble-down booths, so that any of the prevalent diseases spread rapidly to the surrounding villages after market days. The town was traversed by sunken footpaths winding between high mat fences, ankle-deep in expectorated sugar cane. Wooden clogs were worn because of the mud. Stinking borrow

* Colonial Office. Tsetse Flies in British West Africa. By Dr. T. A. M. Nash. Pp. 78+15 maps. 30*s*. net. The Anchau Rural Development and Settlement Scheme. By Dr. T. A. M. Nash. Pp. 22+4 plates. 3*s*. 6*d*. net. Trypanosomiasis in British West Africa. By Dr. T. H. Davey. Pp. 15. 2*s*. net. Trypanosomiasis in Eastern Africa, 1947. By Prof. P. A Buxton. Pp. 44. 3*s*. net. (London: H.M. Stationery Office, 1948.)

and dye pits mingled their smells with the all-prevailing stink of human excrement. For defensive reasons the town had been built on the edge of a marsh, with two tsetse-infested streams on the west and south and, in addition, these flies swarmed in the thicket-choked moat of the town wall which the people refused to clear because of ancient superstitions—but it *was* cleared and Anchau has survived. Mosquitoes came up at dusk from the marsh in their myriads. For years all beasts had been slaughtered on a piece of blood-soaked ground, which was littered with offal and bones, thereby providing a meeting-place for vultures and hyænas, and the dead had to be buried inside the town, to prevent desecration by these ghouls. In the wet season, the guinea corn, fourteen feet in height, choked the few remaining open spaces. Water was obtained from the swamp or from filthy wells sited within a few yards of a pit latrine.

Such is the lurid picture painted of old Anchau, the district headquarters. How all this has been changed, how a model township with brick-built beehive huts in model compounds, with standard types of new wells, spacious well-planned market-place, slaughter-houses, etc., has been built, are well illustrated by a series of excellent aerial photographs. There follows a number of suggestions from the lessons which have been learned. More than 18,500 fruit and shade trees have been distributed throughout the corridor. A successful pig-breeding industry has been started which brings much wealth to the peasant farmer. Tsetse have been eradicated from 610 square miles of country, necessitating the clearing of 540 linear miles of stream, so that now some 50,000 people can live out healthy lives in a tsetse-free country.

There are some amusing interludes, such as the conflicting interests between the afforestation enthusiasts and tsetse-minded entomologists. Thus the planting of innocent papaya trees provided an ideal breeding place for *G. tachinoides* in the middle of the town and they had to be cut down. The presence of sacred trees in the streams caused much trouble. The village headman would suddenly announce that the work was nearing a spot where any man would die who entered the grove, and then work would come to a standstill. This nuisance was soon avoided by inducing the old man to exorcise his evil spirits on to a neighbouring hill, when everyone appeared to be satisfied and the prestige of the gangman was proportionately enhanced. To mark the transition from the bad old days and the transformation from a sink of pestilence, the new town of Anchau has been named Takalafiya, which means "Walk in Health".

Dr. T. H. Davey's "Trypanosomiasis in British West Africa", a rather shorter document of some 15 pages, includes a general survey of West Africa and embraces the Anglo-Egyptian Sudan, French West and Equatorial Africa, the Belgian Congo and Liberia. Though not so detailed as the other reports, it contains a summary of useful information both on human and cattle trypanosomiasis.

In Prof. P. A. Buxton's "Trypanosomiasis in Eastern Africa, 1947", we are presented with a somewhat different problem. Many important points are discussed in the author's own characteristic and philosophical manner in a series of 275 paragraphs and in a space of 44 pages. The situation in East Africa differs in many important particulars from that in the West African Colonies. The geographical features of mountains, valleys and fertile plains present an entirely different picture with its own peculiar vegetation and fauna. Whereas sleeping sickness is conveyed from man to man direct by tsetses in the west, here the human disease is interconnected with big game and the fly which is their constant companion—*Glossina morsitans*. The cattle problem is even more serious, because the wild animals constitute a reservoir of trypanosome infection for them.

The fact has to be faced that, until some better preventive measures are devised, cattle and big game cannot co-exist. An alarming feature is that no doubt serious advances of the fly have recently taken place, especially by the closely related 'game tsetses' (*G. morsitans, G. pallidipes and G. swynnertoni*). This last-named insect was discovered by the late C. F. M. Swynnerton, who was the first to undertake tsetse survey, research and reclamation in Tanganyika in 1921. Swynnerton was a remarkable man, essentially a good naturalist, without any scientific training; but he possessed an immense knowledge of insects, game, plants and Africans, and he could envisage in his own mind the whole problem in a manner no one else has ever attained. More recently, particularly in Tanganyika, field workers have begun to mark flies with spots of paint. This has led to knowledge about their length of life under natural conditions and the distance covered by a fly. A system was then developed, depending on the use of more than one colour, applied to particular spots on the fly, so that it was possible to indicate where and when the fly was first caught, together with information about recaptures. By the use of these methods, entomologists were able to unravel the habits of *Glossina*. They showed that they had particular breeding places, feeding places and resting haunts, and they were able to determine these in terms of characteristic trees and bushes. Much interesting work has been done on the biology of *Glossina morsitans*. This insect lives in a large number of types of vegetation in different parts of its distribution. The greatest part of its range is in 'miombo', a thin deciduous woodland, composed of many types of tree, especially *Isoberlina* and *Brachystegia*; but in other parts it frequents *Acacia* thorn bush, whereas in Ankole, Uganda, it lives in thickets of thorn and other trees growing on large ant-hills in open grassy plains. In all these diverse environments the insect exercises a precise choice, and only feeds, rests or deposits larvæ in very limited spots. It is reasonable to believe that this precise choice, which renders discriminative clearing possible, is partly due to micro-climate.

In Central and North Africa, conditions are generally simpler than in East Africa. The immense geographical variety of Kenya and Uganda, with their high mountains, rift valleys, coastal plains and so forth, is absent. Although *G. morsitans* is the dominant species, yet *G. pallidipes* is also dangerous and has been overlooked in certain areas.

Entomological work in East Africa has been mainly directed from the Tsetse Research Department, Shinyanga. This has already resulted in the settling of large areas in Tanganyika which were formerly occupied by tsetse. The total area reclaimed by this Department is 1,300 square miles. There are now, in the Shinyanga district, 175,000 tax-payers and 525,000 cattle. It is an impressive experience to fly, as Buxton has done, over this area and see cattle and grass and villages where there was at one time only bush and tsetse.

In Uganda, successful control of *G. palpalis* by clearing its waterside breeding places has been practised for many years. Some of these clearings are important because they protect considerable centres of population, especially Entebbe, and they also render safe the ferries where numbers of travellers used to be exposed to the bites of this fly.

The control of tsetse in Southern Rhodesia is essentially a battle against *G. morsitans*. It is the problem of protecting cattle. The principal method employed has been the eradication of game from certain areas, mostly in the higher regions of this territory. Here the Government proposes to make a total of 300–350 farms, each of 3,000 acres, which will be on land formerly occupied by *G. morsitans*.

It has only been possible to select a few of the most important and interesting features which are presented in this most remarkable and original document; but it may convey to the uninformed reader a small idea of the immense effort, both physical and mental, that has been expended by a handful of enthusiastic scientific workers for the benefit and development of the Dark Continent.

It is by a happy coincidence that a summary of this fine preventive work should be published at this very time, furnishing, as it most certainly does, an appropriate setting to the introduction of 'Antrycide', a discovery published in *Nature* of January 15. Together they form a fine consummation of the work of this team of British scientific workers, and undoubtedly bring eventual victory over the tsetse considerably nearer. This is an achievement of which everyone who is interested in the welfare of Africa should be proud, although its full import cannot as yet be measured.

Finally, we venture to assert that these reports, so inadequately here reviewed, constitute a model for the world to emulate. By our good deeds shall we be judged by future generations. Scientific work of this calibre forms the kernel of potent propaganda. We can therefore look forward to such time as the British representative, at some stormy meeting of the United Nations Organisation, can confront his detractors with these mighty African achievements, for no other nation, by its self-effacing and patient labours, has done so much for the health, prosperity and well-being of the untutored Africans whom fate has placed under its care. PHILIP MANSON-BAHR

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# BEE BEHAVIOUR*

By DR. C. G. BUTLER
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FOR many years it has been realized that a well-developed social organisation is exhibited by every colony of honey-bees. We now know, thanks to the work of G. A. Rösch and others, that a highly efficient division of labour exists among the worker bees of a colony, and that each worker bee has her own particular part to play in the economy of her colony. The nature of the duty which a worker performs at any given time is very largely, but not entirely, determined by her age, or, more correctly, by that state of physiological development to which she has attained at the time. But there are no hard and fast rules. If insufficient bees of nursing age are present to feed all the larvæ properly, the period of nursing is extended; similarly, if more than sufficient house-bees are present, their time is not wasted, and the position is readjusted by surplus house-bees becoming foragers at an earlier age than usual. The precise mechanism by means of which such adjustments are made is not yet fully understood.

By the time a bee is three weeks old, she knows the exact position of her hive relative to neighbouring objects in the apiary. If we take a bee of this age and release her a short distance away from her hive, she finds her way home largely, perhaps entirely, by sight. Later, however, as shown by the work of E. Wolf, when she becomes an established forager, two further senses come into play and aid her in finding her way back to her hive. These are a sense of distance travelled, and a sense of the direction in which she has travelled on her outward journey to a source of food.

Even after a bee has successfully relocated her hive on her return from a foraging expedition, she may experience considerable difficulty in finding the entrance if it has been altered in any way. For example, as shown by Butler, if the hive is turned through 90°, she will return to the exact place where the entrance has been hitherto. She settles on the nearest part of the hive to this position and proceeds to run about in all directions, frequently taking to the wing and re-alighting on the place where the hive entrance was situated previously. Eventually, after much running about she locates the entrance in its new position. On her return from subsequent foraging expeditions she does not go directly to the entrance but always goes first to the place where it was originally sited, alights there and runs round on the outside of the hive to the entrance in its new position. Ultimately she learns to fly round to the entrance, but never does so directly, always flying to its original position first and flying from there round the hive to its new location.

In a very similar manner to that in which she is able to find her hive on returning from the field, the honey-bee is also able to relocate a dish of sugar syrup or other source of food that she has found in the field. Provided that the source of food has not been moved, or its surroundings disturbed, the average honey-bee relocates it quickly and unerringly after she has visited it a few times. Let us suppose, for example, that we have placed a dish containing concentrated sugar syrup a short distance, say fifty yards, in front, north, of a fairly strong colony of bees living in an observation hive. It will almost certainly be a matter of hours or even days before a single bee finds the syrup. When a bee does find the dish, however, she settles upon it and proceeds to fill her honey stomach before returning to the hive with her prize. When she leaves the dish she performs a short orientation flight around it to help her to find it again the next time that she seeks it. Let us mark her with a spot of coloured paint so that we can recognize her again. If we watch her on her return to the observation hive, we find, in all probability, that she performs a little dance either on the alighting board of the hive or on one of the combs, every now and then pausing to pass some of the syrup that she has collected to other bees that have been paying close attention to her dancing. Presently, when she has given away the syrup she has collected, some to the house-bees for ripening and storage, and some to the bees of foraging age, she ceases to dance, cleans her eyes and antennæ, and leaves the hive, soon to reappear at the dish of syrup. A number of bees will

* Substance of a Friday Evening Discourse delivered at the Royal Institution on November 5.

have been observed to have been attracted by the dance, and some of them leave the hive while the dancer is still performing and eventually find their way to the dish of syrup, so that the number of bees visiting the dish increases. It will be realized that by means of the dance the bee that had found the syrup in the first place was able to communicate information concerning its existence to other bees. Some of these bees then left the hive to seek the syrup and, having found it, filled their honey-stomachs, made orientation flights around the dish to aid them to relocate it on future visits, returned to the hive and danced in their turn, thus informing other bees of their find.

After a number of bees have found the dish fifty yards due north of the hive and have been marked so that we can recognize them again, let us put out further dishes of syrup of exactly the same concentration, west, east and south of the hive and fifty yards from it in each case. We then find that just as many fresh bees appear at each of the new dishes as appear at the old dish due north of the hive. Thus we see that, so far as we can tell, all the information that the dancing bees were able to convey to their sisters was that syrup was to be found somewhere outside the hive. They did not lead the newcomers to the syrup either by flying along in front of them, by leaving a trail of scent, or anything of that kind. Now let us repeat the whole experiment, except that we add a few drops of perfume, let us say oil-of-lavender, to the first or training dish due north of the hive. Plain unscented syrup is supplied in the other three dishes when they are put out. We now find that all the newcomers collect at the first or training dish only, ignoring the other dishes which contain unscented syrup of the same sugar concentration. It is clear, therefore, that by means of the scent in the syrup which the dancing bees gave to those bees which were attracted by their dances, the dancers were able to communicate to the other bees information concerning not only the presence of desirable syrup somewhere outside the hive, but also the scent associated with the syrup, which scent the following bees then sought, thus being led to the only dish which contained syrup with this scent, the one due north of the hive.

This, then, is part of the language of the bees, a language of dances, which were first described by Prof. K. von Frisch about the year 1923.

Von Frisch described two dances in 1923, a round-dance and a wag-tail dance. He suggested that by means of the round-dance coupled with the perfume of the species of flower from which she has collected the nectar, the dancing bee is able to pass on to other bees information regarding the presence and source of a supply of nectar; and that by means of the wag-tail dance similar information about a source of pollen is given. He did not consider that the dancer was able to indicate the direction in which such a source of food lay or its distance from the hive. Further epoch-making work published by von Frisch in 1946 has shown, however, that it was, as O. W. Park and other observers had thought, incorrect to identify the round-dance exclusively with nectar collection and the wag-tail dance with pollen collection. He stated in 1946 that if the food, whether it be nectar or pollen, is located at the distance of less than about one hundred yards from the hive, a round-dance is performed; if it is situated at a distance greater than one hundred yards, a wag-tail dance takes place. By means of the wag-tail dance a successful forager is able to indicate not only that she has found food at a greater distance than the one hundred yards from her hive and, of course, the perfume associated with that nectar, but is also able, apparently, to give to her sister bees an extraordinarily exact indication of this distance. The distance of the source of food from the hive is indicated by the number of turns, figures-of-eight, in the wag-tail dance that are made in a given period of time. Thus, for example, if the source of food is approximately three hundred yards away, the dancer makes about twenty-eight turns per minute, whereas if it is three thousand yards away she makes only nine turns in the same period of time. The length of the straight run which is interposed between the two loops of the figure-of-eight, and the rate of tail-wagging, increase slightly with increasing distance. Von Frisch does not appear to believe, however, that distance is indicated when the food source is less than about one hundred yards from the hive.

Von Frisch has also shown that the honey-bee is able to indicate the direction in which a feeding place lies, provided that such a feeding place is more than one hundred yards from the hive, by the direction in which she makes the straight run of the figure-of-eight, wag-tail, dance. If the run is made vertically upwards on the comb, this indicates that the feeding place is situated in the same direction as that from which the sun is shining at the time; conversely, if the run is made downwards, the source of food is to be found in the opposite direction to that from which the sun is shining. If the bee runs to the left at a certain angle to the vertical the food can be found at the same angle to an imaginary line drawn between the sun and the hive; and so on. Actually it has been found that the sun can be obscured by cloud without interfering with this direction-indicating mechanism.

It has been found that those bees which become interested in the dance of a returned forager follow her round and thus, presumably, learn the message which her dance conveys.

Now let us consider how a foraging bee, possessing these and many other complicated behaviour patterns, behaves in the field when she is working a more or less homogeneous crop of flowers for nectar. In order to simplify the study, my colleagues and I laid out an experimental field with artificial flowers. Each of these 'flowers' consisted of a Petri dish with a one-pound glass honey-jar full of sugar syrup inverted in it, a small piece of blue porcelain being placed on top of this reservoir to add a little colour. These 'flowers' were regularly arranged at twenty-yard intervals along the arcs of circles, each arc being twenty yards from the arcs on either side of it. The whole experimental area occupied part of a sector, of about 30°, of a circle the centre of which lay near the middle of a fairly large experimental apiary. Each 'flower' was supplied with syrup continuously, and once a number of bees were visiting them regularly the experiments were commenced. One fine day in June 1942, two bees were found to be visiting a 'flower' situated at a distance of about 360 yards from their hives. These two bees were marked so that they could be identified from one another and from all other bees. Continuous observation was maintained at this 'flower', and it was found that these two bees flew between their hive and this 'flower', collecting the syrup and carrying it home with great regularity. In the evening these same two bees were still visiting the 'flower'

and had by this time made about a hundred and fifty return journeys in the day; they continued to visit this same 'flower' on subsequent days and never appeared to visit any other despite the fact that they had to fly over or near to a number of similar 'flowers' containing syrup of equal concentration. The same thing was found to be true of other bees visiting various 'flowers' in the experimental field. It therefore appears that so long as there is an abundance of syrup, or nectar, at a given source, bees will confine their attention to this one source for many hours and even for many days.

If we now proceed from this study of the territorial constancy of one or two bees to that of a small, but nevertheless much larger, population, we find that the same thing holds true. It must be pointed out, however, that although this behaviour is in principle probably the same as that which occurs when bees are visiting a natural crop of flowers for nectar or pollen, the time relationships are not of the same order on a flowering crop as on the dishes, since on flowers the time spent by a bee in collecting a load of food is usually much greater than the time spent by this bee in flying to and from her hive.

A number of observations have, of course, been made on natural crops of flowers such as willow-herb (*Epilobium angustifolium*), sainfoin, white clover, etc.; and it was found that bees do exhibit a remarkable degree of constancy to small patches of selected flowers growing in a large group of flowers of the same species. It appears to be reasonable to conclude from a study of the data obtained in these experiments that the honey-bee does not as a rule wander at random over a crop of flowers, but confines her attention to a small area of any crop, the size of this foraging area depending upon the conditions at the time. For example, if the flowers are scattered, then the foraging area of an individual honey-bee is likely to be much greater in extent than would be the case if the flowers were growing close together. The abundance of the nectar or pollen in the flowers also has a profound effect upon the size of the foraging area of each individual. C. R. Ribbands has shown, for example, that in some instances a single flower may for the time being serve as the foraging area of one or more bees. Of course, the foraging areas of individual bees overlap considerably, and if the population of foragers, and therefore the degree of competition, are sufficiently great, there is a further population of wandering bees superimposed upon this relatively fixed population. There is also, without doubt, a third population which is composed of scout bees which leave their hives without any preconceived ideas about what kinds of flowers they are going to work. Having tried a number of different kinds of flowers experimentally, they probably settle down in foraging areas on that crop which is yielding the richest and most abundant nectar or pollen.

It is now fairly clear that the fixation of an individual bee to any particular area of a crop of flowers of one species, and even to one species of flower, is not rigid, although it certainly appears to be the general rule. If, for example, bees are offered a choice between dilute and concentrated sugar syrup in two sets of dishes that have been placed at random in a given area, they will, unless the degree of competition is too great, congregate on those dishes which contain the syrup of the higher concentration. The same thing has been found to occur when syrup of a given strength and nectar are in competition with one another. Thus in some of his experiments Von Frisch found that it was difficult to induce his experimental bees to remain faithful to the dishes of syrup which they had been trained to visit, because flowers in the district contained nectar with a higher sugar content than that of the syrup in his dishes. Ribbands has also demonstrated that individual bees collecting nectar and pollen in a specially planted garden sometimes leave the species of flower from which they have been gathering food for some time and sample the pollen or nectar in a flower or two of another species. It would appear that should this new source of food prove to be more satisfactory than the previous one, they will often desert their old source and establish themselves in foraging areas on the new; but if it proves to be less satisfactory, they soon return to the old source. Even when they have become attached to a new source, they continue to visit a few flowers of the old source from time to time and may return to it once more.

It appears to be reasonably certain, therefore, that honey-bees do not wander over a crop of different species of flowers at random, visiting first one species and then another; but rather that they quickly become attached to one particular species and to a relatively small number of flowers of this species. From time to time, however, they will visit another species experimentally and, should it prove to be a more profitable source of food than that species, or, perhaps, those species, which they have visited hitherto, each bee will select for herself a foraging area in the stand of this new species of flower, and will remain faithful to it just so long as she does not discover an even more profitable source of food elsewhere.

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## CONCERT HALL ACOUSTICS

THE Acoustics Group of the Physical Society held a meeting on November 4 at the Royal Society of Arts to discuss "Concert Hall Acoustics". The object of the meeting was to bring together musicians, architects, engineers and men of science in a general discussion on concert hall acoustics, with particular reference to the new concert halls for London.

Before describing the discussion, it is important to outline the present state of theoretical knowledge. The most recent major contribution to the theory of acoustics of rooms has been made by P. M. Morse and R. H. Bolt[1]. These authors have analysed the behaviour of sound waves in rooms in terms of wave theory and the appropriate boundary conditions, and obtain exact solutions for rooms of simple shapes, and approximate solutions by perturbation methods for rather more complex shapes. However, the lack of practical knowledge of the acoustic impedance of the materials used internally in concert halls and the complicated shape preclude the direct application of the solutions, and it is necessary to use the simpler concepts of geometrical acoustics. The classical approach of W. C. Sabine[2] in defining the reverberation-time of halls has remained substantially unchanged, and it is Sabine's formula and the minor modifications to it that the architect must use when designing a new hall.

Mr. Hope Bagenal, speaking as an architect, gave a general review of the problem; there is, he said, no consistent London concert-hall tradition. The only contribution was Knightley's Queen's Hall

(seating 2,000) in which convex splays were used round the orchestra to reflect the orchestral sound into the auditorium. Knightley also deliberately introduced resonant wood panelling, and this was effective in absorbing low frequencies and enhanced the balance of tone.

Mr. Bagenal described two older building types. The first was the large baroque theatre of the eighteenth century. Low-frequency absorption was good, due to the use of stucco on wood lath; middle- and high-frequencies were absorbed by the upholstery; and the baroque ornament diffused the sound adequately. These factors produced a very short reverberation-time and no echoes, and hence made possible an extreme rapidity of tempo. The other building type was the Leipzig concert hall derived partly from the halls of the Italian musical academies and partly from the early coffee-house rooms. This type was rectangular with a flat ceiling, giving a good distribution of sound. Boxes in the rear wall prevented echoes arising from end reflexion, but there was less absorption per cubic foot of volume than in the theatres. The reverberation-time was longer and consequently the tone was fuller. W. C. Sabine designed the New Boston Concert Hall (1,100 seats) after studying the Leipzig *Gewandhaus* (1,560 seats), and developed his formula for calculation of reverberation-time from these studies.

At this stage in the development of concert halls it had become possible by the development of empirical methods to build a good hall for an orchestra of 80, choir of 220 and audience of 1,500. But in recent years the requirements have changed. The orchestra numbers 120, choir 400 and the audience 3,000 or more. The baroque ornament has disappeared, and it is necessary to introduce elements to fulfil their acoustic functions and yet be in conformity with modern architectural style. Another modern requirement arises from the fact that in parts, at least, modern compositions are much louder than classical works. In Mr. Bagenal's opinion the largest halls are not suitable for the performance of works containing very quiet passages; in the rear seats these passages may even become inaudible. The maximum permissible distance between an orchestra of 120 and the rear seats is 140 ft., for smaller orchestras 120 ft.

Mr. Bagenal then defined the two main requirements for good concert hall acoustics, 'definition' and 'singing tone'. He explained 'definition' as the rapid delivery to the ear of all the pitch components of each note in a note sequence together with their proper order and beat. It also involves the proper hearing of transients. The design requirements to obtain good definition he described as free, direct paths for the sound, reflectors near to the orchestra, and glossy surfaces to reflect the highest frequencies. There is also the negative requirement of absence of echo. 'Singing tone' was defined as a choral character imparted to strings, and produced by reverberation.

In the light of these requirements Mr. Bagenal discussed two types of hall: the older rectangular type with side galleries, and the newer fan-shaped type with wide rear gallery and ramps. The rectangular type would have reflectors at the sides and above the orchestra. The floor seating could rise only slightly, and the orchestra platform would consequently have to be raised with steep platform risers. The definition might suffer from the screening of some players in the orchestra by others, but the random reflexions from the side walls would give good singing tone. The hearing at the back of the hall would be poor because of the long distance. The fan-shaped type would enable the seats to be steeply ramped, and the orchestra could then be placed on the same level as the front seats, providing good definition for all seats. But to prevent echo from the large rear wall, which is often concave, this wall would have to be absorbent, and this might reduce the reverberation and cause poor singing tone. The rear seats would be better than in the rectangular hall owing to the shorter distance. By the use of convex surfaces in the fan-shaped hall the reflexions can be randomized at will.

There is a modified type of hall which combines some of the features of the two types described above. This type is the stepped fan-shape, that is to say, the opening-out of the plan is achieved by a series of steps in the side walls, thus retaining the parallelism of the side walls.

In all types of hall the placing of the organ is difficult, and in a hall suitable for orchestral music the reverberation-time will be too short for good organ tone.

In the discussion that followed, Sir Adrian Boult, speaking as a conductor, stated that, if forced to choose, he would sacrifice definition for a good singing tone; he considered that the latter is essential for the beauty of music. Another conductor, Sir Malcolm Sargent, in a written contribution, obviously had an entirely different definition of singing tone from Mr. Bagenal's definition. Sir Malcolm referred to singing tone as being a function of the harmonics produced by a given instrument independently of its acoustical surroundings. He defined as 'resonance' in a hall the retention of the higher harmonics of the instruments without excessive absorption. Mr. Geoffrey Sharp, who spoke as a music critic, preferred singing tone to definition, on the somewhat opportunist grounds that at the present time the precision of the playing of orchestras is not sufficient to be affected by the acoustics, and that the singing tone reinforces the usually poor quality of strings. Dr. K. Rankl, another conductor, considered that a hall seating 2,500 people is the maximum size for good acoustics. If the public demand is too great to be accommodated in this size of hall, the same concert should be repeated two or three times. He thought that broadcasting acoustics should not be considered, for the requirements are quite different.

Mr. Clive Entwistle put forward, as an architect, a revolutionary plan to seat 6,000 in an annular hall with the orchestra in the centre. He claimed that the main advantage would be that the farthest auditor would be only 108 ft. from the orchestra, compared with 143 ft. for a fan-shaped hall seating 4,000. Mr. P. H. Parkin, speaking as a physicist, pointed out that this proposal assumed that sound is radiated equally in all directions by an orchestra, which is, in fact, not the case for the higher frequencies. Mr. F. Howes also took up this point as a music critic, and said that the 'address' of orchestra to audience would be lost to half the listeners.

Mr. T. Somerville (B.B.C.) described measurements made in two halls, the New Philharmonic at Liverpool and St. Andrew's, Glasgow. In addition to the usual reverberation-time measurements, pulses of sound at specific frequencies with durations of a few milliseconds were injected into the hall, and the resulting variation of sound pressure with time presented on a cathode-ray tube. In the Liverpool hall the build-up and decay of the sound pressure was uneven, whereas in the Glasgow hall the received

pulses were sharply defined. This pulse technique was also described by Mr. J. Moir (British Thomson-Houston Co., Ltd.), who showed pulse records taken in a cinema. Mr. Moir claimed that this technique is the most useful for investigating hall acoustics, but stated that quantitative interpretation of the results is not yet possible.

Mr. Parkin (Building Research Station) summarized the results of a questionnaire sent to 175 expert listeners (for example, music critics), in which they were asked for their opinions of the acoustics of ten selected concert halls. The replies showed conclusively that the New Philharmonic Hall, Liverpool, was considered to have very good acoustics. The Royal Opera House, Covent Garden, and St. Andrew's Hall, Glasgow, are two other halls generally considered to be acoustically good. This 'operational research' approach, which bases the assessment of the acoustical properties of a hall on a statistical analysis of critical subjective estimates coupled with physical measurements, was also evident in Mr. W. A. Allen's contribution describing a subjective test made in a concert hall by six listeners. These listeners changed their position in the hall between items in a concert, and there was substantial agreement on the acoustic conditions at the various positions. Mr. Parkin also pointed out that since calculation gave only a rough guide when designing a hall, it would be advantageous to adjust the acoustics of a new hall while building, on the basis of measurements made when the hall was nearly finished.

Mr. R. Howarth (B.B.C.) stated that in a war-time B.B.C. studio the broadcasting acoustics were much improved by the replacement of the wooden orchestral platform by a solid structure.

Mr. H. L. Kirke (chairman of the Acoustics Group), in his summing-up, emphasized the value of meetings such as this in bringing together architects, musicians and men of science. It was obvious that exact definitions of the terms used are required, and that further and more detailed collaboration is necessary.

P. H. PARKIN

[1] Morse, P. M., and Bolt, R. H., "Sound Waves in Rooms", *Rev. Mod. Physics*, **16**, No. 2 (1944).
[2] Sabine, W. C., "Collected Papers on Acoustics" (Oxford University Press).

# OBITUARIES

## Dr. James Chumley

ON December 12, 1948, there passed away at his home near Edinburgh at the advanced age of eighty-six, Dr. James Chumley, thus bringing to an end a long life of service to biological science the more worthy of commemoration in *Nature* in view of the fact that most of his work was carried on unseen and unrecorded by publication under his own name.

In the closing years of the nineteenth and early years of the present century, one of the chief centres of zoological activity was the "Challenger" Office, Edinburgh, where John Murray supervised the working out of the immense collections brought home by H.M.S. *Challenger*. From a subordinate position in the office, Chumley rose to become Murray's secretary and right-hand man in the work of caring for the collections, distributing them for investigation by specialists and eventually editing the fifty volumes of "Challenger Reports" which may well be regarded as forming the foundations of the modern science of oceanography. Chumley claimed, no doubt justifiably, to be the only man in existence who had read every word of these reports.

In addition to his work in the "Challenger" Office, Chumley acted as secretary and treasurer of the Scottish Marine Station at Granton, built with funds subscribed by friends of John Murray, by the margin of a great quarry which had been invaded by the sea and converted into an immense natural aquarium. Attached to the Station were a large lighter with deckhouse laboratory moored in the middle of the quarry and humorously designated the *Ark*, and a small research ship of 30 tons, the *Medusa*. The Granton Marine Station served to introduce various zoologists, including the present writer, to the science of marine biology, and incidentally it may be regarded as the ancestor of the important Millport Marine Station of to-day, for the *Ark* and the *Medusa* were taken through the Forth–Clyde Canal in 1884 and utilized in the Clyde area for investigations supplementary to those of the *Challenger*. After the conclusion of this work in 1892, the *Ark* remained at Millport; it was drawn up on the shore and continued to function as a laboratory until destroyed by a storm in December 1900, an extension having already been provided which still exists as part of the present Station.

Murray's plans to return to the Clyde and take over the Millport Station were brought to nought by his sudden death by accident in 1914. The *Challenger* collections were handed over to the British Museum (Natural History), and Chumley was appointed a teaching fellow in the Department of Zoology, and later as lecturer on oceanography, in the University of Glasgow. There he continued to play the same active unobtrusive part as he had in the "Challenger" Office. The arrangement and cataloguing of the large library and the card catalogues of local fauna were in the main the work of James Chumley; and those in the Department of Zoology who published work during his twenty years in Glasgow owe him an inestimable debt for his ever-ready assistance in matters of bibliography and editorial revision.

As already indicated, Murray carried out, as an extension of the *Challenger* work, oceanographical researches in the Clyde sea area. So far as concerns physical oceanography, the results of these investigations were duly worked up by one of Murray's colleagues, H. R. Mill; but the zoological results had remained untouched. This blank Chumley proceeded to fill, and his first two years in Glasgow were devoted to working through the *Medusa* records with the idea of thereby laying a foundation for subsequent faunistic work. The result was his valuable "Fauna of the Clyde Sea Area", published by the Glasgow University Press in 1918. JOHN GRAHAM KERR

## Prof. W. J. Dann

PROF. WILLIAM JOHN DANN, professor of nutrition at the Duke University School of Medicine, Durham, North Carolina, died at his home on December 5. Prof. Dann was born in Bath, England, on November 9, 1904, and graduated at the University of Sheffield in 1925. Later he went to Cambridge, where he received the Ph.D. degree in 1932, after working under the direction of Sir Frederick Gowland Hopkins.

Dr. Dann, who had been at Duke University since 1935, became a recognized authority in the field of nutrition and the study of vitamins. He was a Beit

Memorial Fellow at the University of Cambridge between 1933 and 1937, and was awarded the degree of D.Sc. by the University of Sheffield in 1943.

For many years Prof. Dann served as an editor of the *Journal of Nutrition and Nutrition Reviews*, and as a member of the Institute of Nutrition. He was co-author of the book "The Determination of the Vitamins". At Duke University he did outstanding work and research on pellagra and other deficiency diseases, and the use of nicotinic acid in combating them. His death at the early age of forty-four involves a great loss to the University and to science.

We regret to announce the following deaths:

Prof. L. Farkas, professor of physical chemistry in the Hebrew University, Jerusalem, on December 31.

Prof. Hermann J. Levy, formerly of the Technical College, Berlin, an authority on the economics of industrial assurance and of retail distribution, on January 16, aged sixty-seven.

Dr. J. Gilbart Smyly, formerly regius professor of Greek in Trinity College, Dublin, known for his work on the Tebtunis and the Flinders Petrie papyri, on December 25, aged eighty-one.

# NEWS and VIEWS

## Girton College, Cambridge: Dr. Mary Cartwright, F.R.S.

Miss Mary Lucy Cartwright, whose appointment as Mistress of Girton has been announced, is recognized as one of the leading pure mathematicians in Great Britain. A pupil of G. H. Hardy at Oxford, she gained the degree of D.Phil. at that University, but migrated to Cambridge in 1930, on her election to a fellowship at Girton. Her early work was on Abel summability and Dirichlet series. This was followed by a long series of papers on integral functions and functions regular in angle. Influenced possibly by J. E. Littlewood, she then turned her attention to inequalities for *schlicht* and related functions, and in 1935 made what is perhaps her most striking discovery, the inequality

$$|w(z)| < A(p)\,\mu\,(1-r)^{-2p}$$

for a function which takes no value more than $p$ times in the unit circle. During the War, Miss Cartwright worked in an entirely different field, the theory of non-linear differential equations. The great practical importance of this field has long been recognized; but the mathematical difficulties are very formidable. The subject has advanced greatly as a result of the war-time work of Miss Cartwright, Prof. Littlewood and others. Miss Cartwright was elected a fellow of the Royal Society in 1947, the first woman mathematician to be so honoured.

## Zoology at Sydney: Dr. P. D. F. Murray

Dr. P. D. F. Murray has been appointed to the chair of zoology at the University of Sydney. Dr. Murray, who is a graduate of Sydney, first came to England as a research student to study under Dr. Julian Huxley at Oxford. He then returned to Sydney, where he held a lectureship in the Zoology Department. In 1930, having obtained a Rockefeller travelling fellowship, he returned to England to work at the Strangeways Research Laboratory, Cambridge, and in the same year was awarded the Smithson Fellowship of the Royal Society. He left Cambridge in 1937 to take a teaching post at Bedford College, London, and in 1939 he was appointed to a university readership in biology at St. Bartholomew's Hospital Medical College. Dr. Murray is well known for his studies on the developmental mechanics of the skeleton in embryonic life. In these investigations the potentialities of the mesoderm of the early chick limb-bud were analysed by isolating different regions of the rudiment and studying their development when grafted on the chorio-allantoic membranes of the egg. Dr. Murray also made an extensive series of experiments on the physiology of the heart rudiment, using the tissue-culture technique and observing the effect of various ions on the character of the beat. Recently he has returned to his researches on the problems of skeletogenesis.

## Institution of Electrical Engineers: Capt. J. M. Donaldson, M.C.

Capt. J. M. Donaldson has been elected an honorary member of the Institution of Electrical Engineers in recognition of his distinguished contributions to electrical power engineering, particularly in the fields of generation, transmission and distribution; and for his services to the Institution. Capt. Donaldson was educated at Whitgift Grammar School, Croydon, and at Finsbury Technical and Central Technical Colleges. His first appointment, in 1897, was with the British Thomson-Houston Co., London, and he then studied American methods for four years in the United States and Canada. In 1906, he was appointed general assistant engineer to the North-Metropolitan Electric Power Supply Co., becoming a director of the Company in 1943. Under Capt. Donaldson's technical guidance the 'Northmet' system grew to be one of the largest co-ordinated electric power supply networks in Great Britain. He carried out much pioneer work in the field of supply, particularly in the use of steam at increased pressures and temperatures in the generating plants for which he was responsible. He now serves as a member of the Eastern Electricity Board. Capt. Donaldson was president of the Institution of Electrical Engineers in 1931, and has served as a member of a number of committees of the Council.

## Mr. C. S. Franklin

The twenty-seventh award of the Faraday Medal has been made to Mr. Charles Samuel Franklin for his distinguished work in radio engineering, and in particular for his original studies of short-wave wireless transmitting and receiving circuits and his invention of the beam aerial, by means of which the practical use of short-wave transmission for communication purposes was established. Mr. Franklin was born in 1879 and received his engineering and scientific training at Finsbury Technical College under Prof. Silvanus Thompson. In 1899 he joined Marconi's Wireless Telegraph Co., then known as the Wireless Telegraph and Signal Co., and was continuously associated with research and development in radio engineering with that Company until 1935, when he retired from active work. During his period with the Company, many outstanding developments stood to

his credit, including reaction patents for wireless receiver circuits, the early British broadcasting stations, directional receiving systems for long-wave communication circuits, rotating beam aerials, short-wave wireless transmitting and receiving circuits, and in particular the beam aerial array associated with his name, which was the fundamental invention comprised in the beam system of wireless telegraphy. He also developed the concentric cable system, which is essential in television transmission practice. Mr. Franklin was the first recipient of the James Alfred Ewing Medal, instituted in 1936 in memory of Sir Alfred Ewing and awarded by the Institution of Civil Engineers for specially meritorious contributions to the science of engineering in the field of research.

## American Association for the Advancement of Science: New President

PROF. ROGER ADAMS, head of the Department of Chemistry in the University of Illinois, has been appointed president-elect of the American Association for the Advancement of Science, and will serve as president during 1950. A former president of the American Chemical Society, Prof. Adams has received many honours for his work as a teacher and his research achievements in synthetic organic chemistry, including the Davy Medal of the Royal Society in 1945 (see *Nature*, **156**, 695; 1945). The president of the Association for 1949 is Prof. Elvin C. Stakman, professor of plant pathology in the University of Minnesota. The next meeting of the Association will be held in New York during Christmas week.

## T. L. Beddoes (1803–49)

THOMAS LOVELL BEDDOES, who died by his own hand a century ago, on January 26, 1849, is an intriguing example of a medical man in whom—to use Sir Arthur MacNalty's striking phrase—the twin heritages of Apollo (medicine and poetry) were always striving for the mastery. Eldest son of the eccentric Bristol physician, Thomas Beddoes, and nephew of the novelist Maria Edgeworth, he was born at Clifton on July 20, 1803. Educated at Bath Grammar School, at Charterhouse, and at Pembroke College, Oxford, he published "The Improvisatore" while an undergraduate; but it was "The Bride's Tragedy" that won the praise of the critics in 1822. Abandoning literature for medicine, he went to Göttingen three years later, and as a medical student sat at the feet of Blumenbach, Langenbeck, and Stromeyer. After graduating M.D. at Würzburg in 1832, he practised in Germany and in Zurich. For a time he was engrossed in experimental physiology, and he translated R. D. Grainger's "Observations on . . . the Spinal Cord" into German; his translation apparently was never published. Towards the end of his life his mind became clouded, and there is some evidence to suggest that he inflicted a wound on his left leg, which became gangrenous and had to be amputated. While in hospital at Basle, he took his own life with curare, though apoplexy was recorded as the official cause of death. His macabre play, "Death's Jest-Book", was published in the following year. Despite its extravagant and unbalanced moods, Beddoes' poetry shows true lyrical greatness.

## National Institute of Agricultural Engineering

THE Agricultural Machinery Development Board, which has been responsible during the past seven years for advising on research and development work on agricultural mechanization and on the management of the National Institute of Agricultural Engineering, is now being replaced by a new and independent governing body of the National Institute of Agricultural Engineering. This body will be constituted legally as a company limited by guarantee and without share capital, and will receive grant aid from the Ministry of Agriculture and the Department of Agriculture for Scotland. The headquarters station of the old Institute at Wrest Park and its Scottish station at Howden will be continued under the new organisation. The members of the governing body, consisting of a chairman and twelve members, have been appointed jointly by the two Agricultural Ministers with the advice of the Agricultural Research Council. Communications should be addressed to the Secretary, Ministry of Agriculture and Fisheries, 1–4 Cambridge Terrace, Regent's Park, London, N.W.1.

In accordance with a recommendation of the Agricultural Machinery Development Board, the Minister of Agriculture and the Secretary of State for Scotland have appointed an Agricultural Machinery Advisory Committee, which will be a permanent body and will consist of representatives of the agricultural and agricultural engineering industries and of the interested Government Departments. Communications should be sent to Col. C. K. Hamilton, Ministry of Agriculture and Fisheries, 14–21 Chester Terrace, Regent's Park, London, N.W.1.

## The National Central Library

THE thirty-second annual report of the executive committee of the National Central Library, covering the year ending February 29, 1948, again refers to a considerable increase in the services of the Library to all the categories of libraries with which it is in co-operation. Issues from or through the Library during the year reached 84,889, an increase of 28·6 per cent on the previous year; of these, 8,655 were to university libraries, as against 6,073 in 1946–47, and 7,823 to the libraries of Government departments, research and industrial organisations, etc. Issues from the Scottish Central Library for Students increased from 13,690 to 15,547, and from the Irish Central Library for Students from 12,893 to 13,082. Twelve further special libraries have been added to the group of "Outlier Libraries", which now numbers 189, and 15,023 books were lent by these libraries during the year, as against 11,289 in the previous year. There are now 589 libraries co-operating in the regional systems and in the London borough libraries interlending system, and 142,832 books were lent by these libraries to other libraries in their own system during the year, as against 120,992 in 1946–47. Loans to foreign libraries during the year increased to 325, and 82 books were borrowed by British libraries from foreign sources. The Bureau of American Bibliography continues to demonstrate its value as the main source of information about American books and periodicals, and 123,270 further entries were made during the year in the main catalogues of the National Central Library, in Wales and in Scotland. Steady progress is now being made with the Union Catalogue of Russian Books and Periodicals, and the Library has also added to its activities that of a National Book Centre to co-ordinate the interchange and distribution of otherwise 'unwanted' publications. The report stresses the

serious position caused by the continued shortage in book production, and records some increase in staff and a start on preventive repairs on the devastated portion of the building at Malet Place, London.

## Spiritual Approach to Physics

UNDER the title "The Value of the Individual", Mr. F. I. G. Rawlins, in Occasional Paper No. 5 of the British Social Hygiene Council, asks physicists to look beyond their immediate pre-occupations. Physical science, he argues, arrives at a point where it can go no further; but this does not justify the assumption that there is nowhere further to go. Modern physical theory cannot (with Laplace) postulate a universe which is a self-maintaining system, about the origins or destiny of which it is superfluous to inquire. The step from physics to theology is not compulsory; but there is nothing to prevent it and a good deal to encourage it. Only when that step is taken can the universe be seen as an environment with a meaning, where human personality is able to realize itself.

## Anatomy and Physiology of Acrididæ

UNDER the title of "Recent Advances in Acridology", Dr. B. P. Uvarov contributes a general survey of the literature on the anatomy and physiology of locusts and grasshoppers. It covers the period that has elapsed since the publication of the same author's book, "Locusts and Grasshoppers", in 1928. During the interval of twenty years the titles of nearly 2,500 papers, published in twelve languages, have been added to the bibliography that is kept up to date at the Anti-Locust Research Centre in London. The present survey is intended to provide a digest of all publications bearing upon anatomy and physiology. Other surveys dealing in particular with development, ecology, control, etc., will follow. The object of these digests is to further research and investigation by making the relevant literature more easily found. Particular attention has been paid to collating widely scattered data and papers that are not readily accessible. The present survey appeared, under the title given above, in the *Transactions of the Royal Entomological Society of London*, vol. 99, Part 1, pp. 1–75, 1948, and has been reprinted as "Anti-Locust Bulletin No. 1" by the Anti-Locust Research Centre, British Museum (Natural History), London, S.W.7. It is to be obtained in exchange from the Anti-Locust Centre, or may be purchased from the Royal Entomological Society, 41 Queen's Gate, London, S.W.7 (price £1 4*s*.).

## Physical Society: Meeting at Edinburgh

A ONE-DAY meeting of the Physical Society will be held on February 19 at the University of Edinburgh, in the Department of Natural Philosophy. The morning session will include three papers on developments in electron focusing: T. H. Braid and H. O. W. Richardson will describe tests of a wide-angle β-particle spectrometer; R. E. Siday and D. A. Silverston will discuss tests of a prism spectrograph; and A. N. Barker, Prof. N. Feather and H. O. W. Richardson will describe an emission microscope for photo-electron autoradiography. A paper on the use of proportional counters to investigate β-disintegration will be given by S. C. Curran, and a paper on electrons as nuclear projectiles by B. Touschek. In the afternoon session, subjects to be discussed are: a new approach to the theory of elementary particles, by Prof. M. Born and H. S. Green; film transport in liquid helium II, by Prof. J. F. Allen; a new photo-electric amplifier, by R. V. Jones; and long-range molecular forces, by J. Iball.

## Announcements

SIR HAROLD SPENCER JONES, Astronomer Royal, has been awarded the Catherine Wolfe Bruce Gold Medal for 1949 of the Astronomical Society of the Pacific, for distinguished services to astronomy.

PROF. P. M. S. BLACKETT, Langworthy professor of physics in the University of Manchester, has been awarded the Dalton Medal of the Manchester Literary and Philosophical Society, in recognition of his outstanding contributions to the advancement of our knowledge of physics. This Medal has been awarded on six previous occasions, as follows: Edward Schunck (1898), Sir Henry Roscoe (1900), Prof. Osborne Reynolds (1913), Sir Ernest (Lord) Rutherford (1919), Sir J. J. Thomson (1931), Sir Lawrence Bragg (1942). The presentation will take place at a conversazione with which the Society will open the new session in October 1949.

THE first award of the "Medal for Service in Agriculture and Forestry" of the Institute for International Relations in Agriculture and Forestry in Prague has been made to Prof. Dontcho Kostoff, director of the Institute for Applied Biology and Organic Development at the Academy of Sciences, Sofia, and professor of plant breeding and evolution in the Faculty of Agronomy, for his monograph, "Cytogenetics of the Genus *Nicotiana* (1941/1943)", on the ground that it is the most noteworthy book in the Slavonic languages published during the last few years.

MR. J. W. TULLO has retired from the post of chief chemist to Messrs. Arthur Guinness, Son and Co., Ltd., Dublin, with whom he has been associated for the past fifty years. He has been succeeded by Mr. J. Andrews.

DR. F. A. FOX, deputy director of the British Welding Research Association, has been appointed deputy technical manager of Messrs. H. J. Enthoven and Sons, Ltd., London, E.C.3.

THE Fifty-fifth Conference of the Deutsche Gesellschaft für innere Medizin is due to take place in Wiesbaden during April 25–28, 1949. The chief themes for discussion will be: protein exchange; chemotherapy; circulation problems; and psychosomatic medicine and neuritis.

A COURSE of six lectures on "Electronics in Industry" will be given at the Electrical Engineering Department of The Polytechnic, 309 Regent Street, London, W.1, by Mr. L. I. Farran. The lectures will be given on Fridays at 6.30 p.m., commencing February 4, 1949, and the fee for the course is 10*s*.

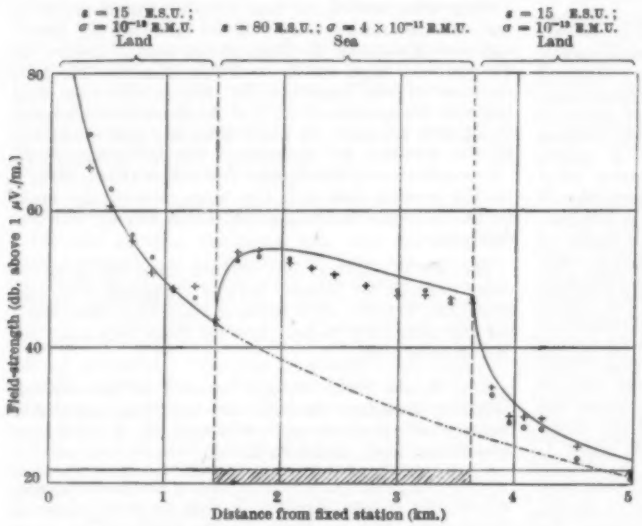
THE University of Oxford has accepted the generous gift from the American Cyanamid Company, Stamford, Connecticut, of a Perkin Elmer infra-red spectrometer with recorder and accessories. This has been installed in the Physical Chemistry Laboratory under the supervision of Dr. H. W. Thompson, and will be used for spectroscopic investigations of a fundamental character, and particularly with regard to problems of biochemical importance. In the latter connexion it is hoped to undertake co-operative work between several of the University laboratories at Oxford.

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Ground-Wave Propagation Across a Land/Sea Boundary

In a paper to be published shortly[1], I have discussed the problem of ground-wave transmission across a land/sea boundary, and have predicted that under some conditions there should be a marked recovery in field-strength. On medium wave-lengths this recovery should extend to a considerable distance over sea, though, so far as I am aware, no conclusive evidence of this phenomenon has yet been published. The theory shows that the effect should not be confined to the diffraction region; but that on sufficiently short wave-lengths it should occur at distances where the Sommerfeld flat-earth analysis is valid.




———, Theoretical curve, land and sea; — · — · —, theoretical curve, land only; +, measurements at fixed station; o, measurements at mobile station. $\lambda = 3{\cdot}9$ m.; $P = 10$ watts; vertical polarization, $h_T = h_R = 0$

For vertical polarization on a wave-length of 4 metres, the recovery should be well developed when the land/sea boundary is only a kilometre from the transmitter, and the maximum increase in field-strength when both aerials are on the ground should then be of the order of 12 db. and occur at about 0·5 km. beyond the boundary. Experimentally, these conditions are favourable for the finding of a suitable site free from irregularities of terrain comparable with the wave-length, and for obtaining adequate field-strengths at the required distances with a portable transmitter. The expected increase is also greatly in excess of any likely instrumental or site errors.

Fortunately the Marconi crystal-controlled transmitter-receiver *H*.16 working on 77·575 Mc./s. ($\lambda \approx 3{\cdot}9$ m.) is ideally suited for the purpose, giving a radiation of 10 watts from a vertical half-wave dipole and permitting two-way transmission and reception with telephonic communication. An experiment has been carried out using one such set as a fixed station on the Mundon Marshes south of the Blackwater, Essex, while another was moved from it along a straight line to the shore 1·4 km. away, and then across the sea path of 2·2 km. in a motor-boat. Field-strength readings were taken at high tide at each station at intervals along the land- and sea-paths, and at a number of points on the land on the farther side.

The results are shown in the accompanying graph. On this wave-length the propagation over land is controlled mainly by the permittivity, and a value of 15 E.S.U. deduced from the shape of the initial land curve has been taken in computing the theoretical curve. The assumption that the propagation is unmodified before a boundary is effectively fulfilled, and the test confirms the prediction as regards both the extent and the position of the recovery. It also affords an interesting check of the reciprocity condition over such a composite path.

The measurements over sea were conditioned by the necessity of stopping the engine of the boat while taking a reading and the consequent drift off course. The low values may be accounted for by obstructions on the modified land path, in particular a section of sea wall lying along the path. To overcome this difficulty, a continuous recording was made at the fixed station of the signal from the mobile transmitter while the boat kept on its course at uniform speed, and the curve so obtained agrees closely with the theoretical curve over the whole of the sea path, including the initial rapid rise of field-strength.

The terrain on the farther side was less favourable for unobstructed transmission, involving the choosing of measuring sites considerably off course; but the values confirm the correspondingly rapid drop in field-strength that occurs on crossing a sea/land boundary. On this wave-length the theoretical curve would eventually settle down to the all overland curve if the sea section were somewhat farther from the transmitter.

The theory is admittedly approximate, but this confirmation at a short wave-length strongly supports the explanation I have given of these effects in terms of a redistribution of energy above the ground, whereby the height-gain relation on one side of the boundary changes to that characteristic of the section on the other side, and strengthens one's confidence in the use of the theory on medium and long waves, where the results can be of profound practical importance.

G. Millington

Research Division,
Marconi's Wireless Telegraph Co., Ltd.,
Great Baddow,
Essex.
Dec. 7.

[1] *J. Inst. Elect. Eng.* (in the press).

## Tolerance Flux of Thermal Neutrons

THE danger of neutrons on the human body arises from two factors: the slowing down of fast neutrons and the absorption of neutrons. In the case of thermal neutrons, only absorption can take place, either in hydrogen to form a deuteron with emission of a 2·2-MeV. γ-ray, or by nitrogen-14 to form a carbon, with the emission of a 0·7-MeV. proton. In a very complete paper on the subject, Mitchell[1] finds that the ionization produced in the human body can be attributed half to the γ-rays of the latter reaction and half to the protons. This note deals only with the γ-rays from the H(*n*,γ)D reaction.

Mitchell starts from the idea that the distribution of neutrons in the body is given by an exponential function, and he works out the ionization produced at the surface by γ-rays liberated in the semi-infinite medium. With a diffusion length of 2·8 cm. he finds that the maximal dose is attained with an incident flux of thermal neutrons of the order of 1,000–2,000 neutrons/cm.²/sec.

It is well known that the ordinary theory of diffusion of thermal neutrons cannot be applied near a discontinuity (the surface of the body in this case), and as we expected that a purely exponential function would be invalid and could vitiate the result quite a lot, we have set up an experiment to determine the true distribution function with a thermal neutron source outside a paraffin block. This source was a 2,400-mc. radium–beryllium source in a howitzer from which neutrons are 'focused' on to a paraffin block 50 cm. away. The detectors were rhodium plates 0·05 gm./cm.² irradiated for five minutes, the activities of which were measured on both sides of the detector. Those detectors were irradiated at different depths inside and outside the paraffin and in such conditions that the contribution from the different kinds of neutrons could be determined. The results are shown in Fig. 1. Curve *A* gives the total activity of the rhodium; curve *B* gives the activity when a large cadmium screen completely shielded the paraffin block; this activity being due, therefore, to the resonance neutrons and the thermal neutron by-products of the resonance slowed down to thermal energies. Curve *C*, with the rhodium plates completely shielded in a cadmium envelope, gives the distribution of resonance neutrons. Curve *E* (equals *A* − *B*) gives the distribution of thermal neutrons only.

Activities measured at the surface and outside the paraffin cannot be attributed to neutrons travelling in the direction howitzer–paraffin only, but also to neutrons scattered and diffusing back in the direction paraffin–howitzer. It can be calculated that, in our experimental arrangement, 65 per cent of outside and surface activities comes from neutrons travelling in the direction howitzer–paraffin. The neutron distribution function is then given by:

$$N = N_0 \{2{\cdot}55 \exp(-x/L) - \exp(-x/l)\},$$

for an incident flux of $N_0$ neutrons/cm.²/sec., and with $L = 2{\cdot}1$ cm. and $l = 0{\cdot}38$ cm., equal to the thermal neutron data as given by Fermi[2].

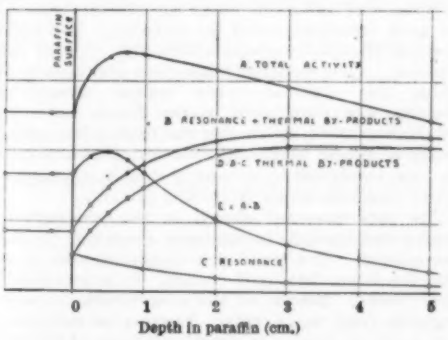


Fig. 1

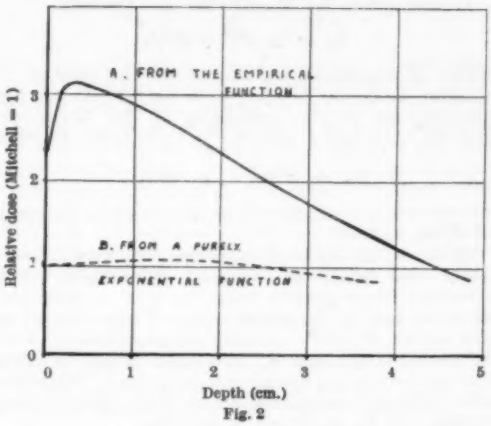


Fig. 2

This result is the outcome of, on one hand, an inside diffusion of neutrons, and, on the other, near the surface there is a leakage up to a distance which is of the order of the mean free path.

We have worked out the ionization arising from such a function at the surface as well as in depth, and extended Mitchell's calculations in depth for a purely exponential function (full details will be published elsewhere); the results are as follow:

(1) For a given incident neutron flux the surface dose is double that worked out by Mitchell (Fig. 2).

(2) The ionization dose passes through a maximum at 0·3 cm. with an intensity three times Mitchell's value.

To keep within the limits of the maximum tolerable dose, and taking into account the contribution of the N(*n*,*p*)C reaction, we suggest that the maximum flux of incident neutrons should be limited to about 500 neutrons/cm.²/sec.

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[1] Mitchell, *Brit. J. Rad.* (Feb. 1947).
[2] Fermi and Amaldi, *Phys. Rev.*, **50**, 899 (1936).

## Method of Steepest Descents in X-Ray Analysis

IN the method of steepest descents, atomic co-ordinates are derived by minimizing a function of the observed and calculated structure amplitudes. Hughes[1] minimizes $\Sigma w (F_o - F_c)^2$, where the weighting factors are $w \sim 1/F_o^2$ when $F_o > 4\ F_t$, and $w \sim 1/16\ F_t^2$ when $F_o < 4\ F_t$; $F_t$ is the threshold value of the measurement. As the errors do not obey Gauss' law, this formula does not give the best least-squares solution.

It was shown by Vand[3] that the formula

$$R_2 = \Sigma (F_o^2 - F_c^2)^2,$$

which is minimized by Booth[2] by the method of steepest descents, is applicable only when all the observations of the intensities of the X-ray reflexions have equal weight. A logarithmic formula

$$R_3 = \Sigma (\log I_o - \log I_c)^2$$

was then recommended for a case where all the signs of $F$ are known.

It can be shown both experimentally and theoretically that when the assumed co-ordinates of a structure differ greatly from the true co-ordinates, as is the rule in the initial stages of approximation, the errors $F_o - F_c$ increase proportionately with increasing Miller indices. This effect should be taken into account when assessing their weight. When the effect of the observational errors of the intensities on weight can be neglected, a function

$$R_4 = \Sigma \frac{(F_o - F_c)^2}{(h^2 + k^2 + l^2)}$$

should then be minimized. It is possible to derive more general formulæ which take into account the effect on weight of both Miller indices and of experimental errors simultaneously. They deserve closer study but seem to be too cumbersome for practical application. At the initial stages, $R_4$ should thus be preferred, until a stage is reached when no more changes of signs of $F$ are expected, or when the discrepancies are due to experimental error in $F_o$ rather than to incorrect co-ordinates; then $R_2$ should be used. Fewer steps are then required than if $R_2$ were used throughout, as the correct assessment of weights has a great effect on the rapidity of convergence towards correct structure as well as on the accuracy of the final co-ordinates.

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## Investigation of the Distribution of the Radioactive Elements in Rocks by the Photographic Method

In a previous communication in *Nature*[1], a brief account of the use of nuclear plates for the measurement of the total radioactive content of rocks has been given. The results showed that the distribution of the radioactive elements in rocks is not uniform, and that for some rocks quite large concentrations occur.

In order to investigate this effect more fully, a slightly different technique has been adopted. A standard microscope slide of the rock to be examined is made, but the cover glass is omitted, so that the α-rays from the rock can affect a nuclear plate placed in contact with the slide. Both slide and plate are placed in a specially constructed brass frame, in which they are held against three definite contacts, so that either slide or plate can be removed from the frame and replaced in nearly exactly the same position. Microscopic tests showed that this condition is quite accurately fulfilled. It is most convenient first to place the nuclear plate in the frame, film side up, and then put the microscope slide on top with the rock slice down. The desired exposure can then be given and the slide and plate removed for the development of the plate. The frame is now placed on the mechanical stage of a microscope and the plate replaced in it. The distribution of the α-tracks on the plate can now be correlated with the rock minerals, by replacing the rock slide on top of the plate and slightly altering the focus of the microscope. Polarized light can be used for the identification of these minerals in the usual manner. Since the rock slice has to be examined through the glass slide, only a moderate power objective can be used for the purpose. We found a Leitz No. 3*A* suitable.

It may be mentioned that both Mme. A. Hée[2] and E. E. Picciotto[3] have described similar techniques for using rock slides; but neither technique seems to be as convenient.

The first rock to be examined by this method was a Kuru granite from north of Tammerfors (Tampére), Finland. In a total area of about 8 cm.[2] of rock examined, 45 concentrations of α-tracks were observed. Of these, 33 appeared to be due to small yellowish-brown crystals usually associated with the biotite in the section, two due to small colourless crystals, and in seven cases no obvious source in the rock structure could be detected. The accompanying photomicrograph shows the type of result obtained. The photograph has been obtained by first taking the nuclear plate image alone, then inserting the rock slide in the frame on top of the nuclear plate, refocusing the microscope, and exposing a second plate. The resulting two negatives are then combined by means of double printing, and a new negative made from this positive.

The dark material shown in the photograph is biotite, and the light background a mixture of felspar and quartz. The small yellow crystal can be seen near the lower left-hand corner. It is traversed by dark cracks. Nearly all the α-ray tracks appear to originate from this crystal. It must be remembered that a certain spread in the distribution of the tracks

will occur owing to the emulsion not coinciding exactly with the radioactivity source due to the finite thickness of the rock slice and of the air film between the slice and the plate.

The total number of particles in the concentration, as shown on the original negative, is 157. Very few $\alpha$-rays seem to originate definitely from either the biotite or the quartz and felspar. The nuclear plate was exposed to the rock slice for about ten days.

An attempt to identify the yellow crystals has been made by petrological methods. We would wish to thank Prof. L. B. Smyth and Mr. J. C. Brindley for their assistance in this matter. The crystals are non-pleochroic, isotropic and of high refractive index. The known constituent minerals of Kuru granite are microcline, orthoclase, quartz and biotite, with ilmenite and zircon as accessory minerals[4]. Both Prof. Smyth and Mr. Brindley consider that the crystals are probably melanite; but Brindley suggests perovskite as an alternative.

The absolute radioactivity of the crystal shown may be roughly estimated from the number of $\alpha$-particles emitted. Assuming that the crystal is tabular in form, and that its thickness is the same as that of the rock slice, and that its radioactivity is due only to uranium in equilibrium with its products, we find that it must contain about 0·3 per cent of uranium by weight to emit the particles observed, if the density of the crystal is about 4 gm./c.c. This would seem to show that the crystal cannot be a pure uranium or thorium mineral. This is confirmed by the fact that about 40 per cent of the yellow crystals show no concentrations.

It may be possible to identify these crystals by further investigation, and work on this problem, and other rocks, is proceeding.

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[1] *Nature*, **161**, 884 (1948).
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## Co-ordinate Operators in Quantum Mechanics

It has been suggested that co-ordinates should be represented in the quantum theory by operators analogous to those which represent orbital angular momentum[1].

Thus, the co-ordinate $x$ is to be replaced by $a\left(x\frac{\partial}{\partial \eta_0} - \eta_0 \frac{\partial}{\partial x}\right)$, where $a$ denotes a length and $\eta_0$ an additional co-ordinate. If $\eta_0$ be identified with the fifth co-ordinate occurring in the theory of Kaluza and Klein with the limitations, in accordance with the requirements of physics, that $\frac{\partial}{\partial x^5} = 2\pi i m_0 c/h$ and $x^5 = h/m_0 c$, where $m_0$ is the mass of the particle located, it follows that the $x$-co-ordinate operator should take the form

$$X = x - \frac{h}{m_0^2 c^2} u_x, \qquad (1)$$

where[2]

$$u_x = \left(\frac{h}{i}\frac{\partial}{\partial x} - \frac{e}{c}\varphi_x\right).$$

The various symbols are in common use and need not be explained in detail. The fact that the orbital angular momentum operators do not completely describe the angular momentum of a fundamental particle but require also the expression for the spin suggests that these co-ordinate operators likewise require the addition of an analogous expression. The group of angular momentum and co-ordinate operators can be regarded as forming a single tensor[3]; and from this fact it is suggested that the co-ordinate should be extended so that it takes the form

$$X = x - \frac{h}{m_0^2 c^2} u_x + \frac{ih}{2m_0 c} \beta\alpha_x, \qquad (2)$$

where $\beta$ and $\alpha_x$ denote Dirac matrices.

There are similar expressions for the other co-ordinates and there is a time operator, $X_4$, with

$$X_4 = x_4 - \frac{h}{m_0^2 c^2} u_4 - \frac{h}{2m_0 c} \beta, \qquad (3)$$

where

$$x_4 = ict \text{ and } u_4 = \left(\frac{h}{i}\frac{\partial}{\partial x^4} - \frac{ei}{c}\varphi\right).$$

The second terms on the right in expressions (2) and (3) mean that a minimum proper time of magnitude $h/m_0 c^2$ is to be associated with a particle[3] of rest mass $m_0$. This shows that a definite extent is to be associated with a moving particle which is, however, small when the velocity of the particle is small in comparison with that of light. The last term of expression (2), like the corresponding term representing the spin, means that an intrinsic property is to be associated with the particle. Neglecting the second term, the proper values of $X$ are $(x \pm h/2m_0 c)$. An interpretation of this is that, if the co-ordinate $x$ is chosen in the usual way, the particle is described as being located at

$$(x + h/2m_0 c) \text{ or } (x - h/2m_0 c)$$

and not at any point within these limits. This indicates that a finite length $h/m_0 c$ is to be associated with the particle.

If $X$ is differentiated with respect to time in accordance with the rule of quantum mechanics, it is found that

$$m_0 \dot{X} = -\beta u_x - he\,(\vec{E} + \vec{H} \times \vec{\alpha})_x / m_0 c^2, \qquad (4)$$

where $\vec{E}$ and $\vec{H}$ denote the electric and magnetic field intensities, under the influence of which the particle is in motion. This is an interesting result, because it introduces into quantum mechanics a relation which corresponds to the familiar definition of classical mechanics, namely,

$$\text{mass} \times \text{velocity} = \text{momentum}.$$

The old form is retained exactly only in the case when there are no forces, but the relation does not occur at all in the usual form of quantum mechanics.

The additional term in (4) shows how the definition is modified when the particle is accelerated, just as expression (2) shows how the co-ordinate is modified when the particle is in motion.

It also follows that, except for a small imaginary term, Dirac's equation becomes

$$\alpha_x\dot{X} + \alpha_y\dot{Y} + \alpha_z\dot{Z} - i\dot{X}_4 = c, \qquad (5)$$

which means that the velocity operator on the left of this equation has the proper value equal to the velocity of light. Finally, these expressions suggest that a solution of certain difficulties, which appear to indicate the necessity of a quantized space-time, is to be found, not in an intrinsic property of the space of physics, which possibly has no properties except those given to it by the geometer, but in an intrinsic property of matter.

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## Pulse Excitation of Impedance Bridges

In the measurement of resistance in a Wheatstone bridge it is customary to use either D.C. or sinusoidal A.C. as excitation. The former is inconvenient if it is desired to use a valve amplifier as the bridge detector; the latter requires a balance of the residual quadrature component and does not indicate directly the sign of the out-of-balance condition of the bridge.

It has been found that for certain purposes the use of rectangular pulses of suitable length and recurrence frequency as excitation for a bridge offers some advantages. In the case of a resistive bridge with stray capacitance shunting one or more arms, the presence of the capacitance causes a spike with an exponential decay at the beginning and end of the pulse, which appears at the output terminals of the bridge, while the plateau which follows the spike gives a correct indication of the resistive balance condition. Investigation shows that measurements can be made in many practical cases with pulses of from 1 to 10 microsec.; while with sinusoidal excitation under similar conditions frequencies as low as 150 c./s. may be required to make the quadrature component in the bridge output negligible.

One of the most important advantages of the method is that it enables a number of bridges to be excited in sequence and their output applied to a common amplifier. This is the subject of a provisional patent application (J. G. Yates and Elliott Bros. (London), Ltd., No. 22756/47) in connexion with multi-channel resistance strain-gauge equipment. In particular, this avoids the problems of low-level electronic switching for the bridge outputs and replaces it by the easier problem of pulsing the bridge inputs.

The use of pulse excitation is not restricted to the measurement of resistance. For example, the use of pulse excitation in a capacity bridge can provide a convenient method of distinguishing between series and shunt losses in the condenser without requiring measurements at several frequencies.

Some experimental work has been done in collaboration with the Research Laboratories of Elliott Bros. (London), Ltd., and it is hoped to publish further details later.

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## Acclimatization to Cold in the Antarctic

During a year spent as medical officer to the Falkland Islands Dependencies Survey in the Antarctic at Marguerite Bay, I had the opportunity of making some observations on cold acclimatization in eleven men.

In winter and spring, the temperature varied mainly between 0° and − 35° F., though in summer temperatures just above freezing were common in the day-time. It was found that as the weather grew progressively colder with the advent of winter, little additional clothing was required. A fair amount of individual variation in clothing worn was noted, though for any given individual little increase in clothing was necessary. One man, for example, wore a string vest, long woollen underpants, an army shirt, silk scarf, socks, boots, gloves, cap with protection for the ears, thin windproof trousers and anorak (windproof upper garment with hood). This was worn for outdoor walking at temperatures down to 0° F. In colder weather later in the year, a long-sleeved sweater, warmer footgear and gloves were all that was necessary in addition. Apart from the footwear and protection for the ears, this was less than the same man was accustomed to wear in England in winter.

In winter, very exceptionally, the temperature rose from the region of − 20° F. to + 32° F. overnight, and most of the men complained of the discomfort of this relative heat wave.

Difficulties in attempting physiological research on a polar expedition are legion and account for a curtailment of the programme of investigation.

Some of the investigations were to verify interesting results reported by Frazier of the United States Antarctic Service[1], who quotes Lockhart's work. It was found, for example, that the basal metabolic rate in winter at the base in the Ross Sea was lowered paradoxically. Siple has attributed this low rate to a hibernation mechanism. It is, however, logical that in low environmental temperatures the basal metabolic rate should be raised to provide a greater output of body heat. It is a well-established fact that there is a marked rise in the metabolic rate when an animal is chilled[2,3], and this rise is attributable to an increased secretion of adrenaline with increased muscular tone and shivering[3,4]. Many observers have recorded a seasonal change, the basal metabolic rate being raised in winter and lowered in summer[5,2]. Martin[6] has observed a lowered basal metabolic rate in the tropics. Crile[7] records a raised basal metabolic rate in Eskimo, but this may be due to the specific dynamic action of a meat diet. Basal metabolic rate estimations made in winter in the Antarctic at Marguerite Bay showed an average increase of 5 per cent over a set of normal controls with the same apparatus. All estimations were made with the subject comfortably warm in bed. A likely explanation of the discrepancy between these results and those of Lockhart may be that the difference is due to a relative overheating of the United States Antarctic Service huts.

Correlated with a raised basal metabolic rate and increased adrenaline activity, one might expect a raised blood-sugar level, as is found in animal experiments[4]. Lockhart is reported to have found a raised blood-sugar level in his subjects[1]. I found an average increase of 10 mgm. per cent in the fasting blood-sugar, determined by the method of Hagedorn and Jensen, in the comfortably warm subject in winter in the Antarctic.

Frazier[1] noted an increased liability to shock following injection of a preparation of novocaine with adrenaline as a local anæsthetic. He suggested that this might be due to an increased sensitivity to adrenaline, whereby the cold-acclimatized man utilizes his adrenaline to fullest advantage. This possibility was investigated by injecting intravenously 1 c.c. of 1 in 150,000 adrenaline over a period of 90 sec. A slight increase in sensitivity as indicated by changes in the blood pressure, respiration-rate, pulse-rate and subjective sensations was noted in the cold-acclimatized man.

The capacity to work with exposed hands at low temperatures varies considerably. The physiological factor involved appears to be the reaction of the peripheral vessels to exposure to cold[9]. The reaction of the peripheral vessels to cold is influenced by the basal metabolic rate, there being less vasoconstriction if it is high[10]. A variable increase in blood pressure results from the immersion of an arm in ice-cold water for one minute (cold pressor test). This increase in blood pressure is due to stimulation of the vasomotor centre by cooled blood and by afferent impulses from the cooled skin, resulting in generalized peripheral vasoconstriction, including constriction of the digital arteries and arterioles[11]. To a lesser degree this rise in blood pressure may be due to the local effect of cold on the arterioles of the cooled hand. Fifteen men of the Falkland Islands Dependencies Survey were arbitrarily graded according to their tolerance to exposure of the hands to cold. It was observed that those who responded to the cold pressor test by a marked rise in the blood pressure suffered badly from cold hands. However, a man that suffered more than the average from cold hands did not necessarily show hyper-reaction to the cold pressor test.

In conclusion, I should like to pay a tribute to the fortitude of my comrades, who were prepared to be made the subjects of the investigations under trying conditions.

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[1] Frazier, R. G., *Proc. Amer. Phil. Soc.*, United States Antarctic Service Report, **89**, No. 1, 249 (1945).
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## Effect of Oxygen on the Frequency of Chromosome Aberrations Produced by Alpha-Rays

In testing the hypothesis that the effect of ionizing radiations on the growth-rate of *Vicia faba* root tips is primarily due to the production of chromosome aberrations, we have shown[1] that X-irradiation under anaerobic conditions has a much reduced effect on growth, and that this is accompanied by a considerable reduction in the number of cells showing bridges or fragments at anaphase. We have now done an analogous experiment with alpha-radiation, using a modification of the method of Gray and Read[2] of immersing the roots in radon solution. Four graded doses were given to groups of eight beans in oxygen-free water, and four in water that contained 12 c.c. oxygen per litre. The mean growth of the groups of roots in the ten days following irradiation is plotted against dose in Fig. 1, together with comparable curves obtained after X-irradiation. We note that oxygen has a much greater influence on the effect of X-rays than on the effect of alpha-rays, the dose ratios for equal growth 'without/with oxygen' being $\sim 2{\cdot}5$ and $\sim 1{\cdot}3$ respectively.

For the cytological study, two radon seeds of equal strength were selected, and the conditions of the two irradiations were kept alike, except that the water contained 12 c.c. oxygen per litre in one case and none in the other. The application of a few small corrections resulted in estimates of the doses of 7·66 energy units[3] with oxygen, and 8·02 energy units without oxygen. Root tips were fixed at intervals up to 72 hours after treatment. Feulgen squashes were made, and a hundred anaphases were examined in each to determine the percentage that showed bridges or fragments. At six times of graph 1 and seven of graph 2 the data were obtained from two root tips, and, at the remainder, from one. Except in one case the two data have been combined, as their mean was within the standard deviation of each. The results, Fig. 2, suggest that the yield of aberra-

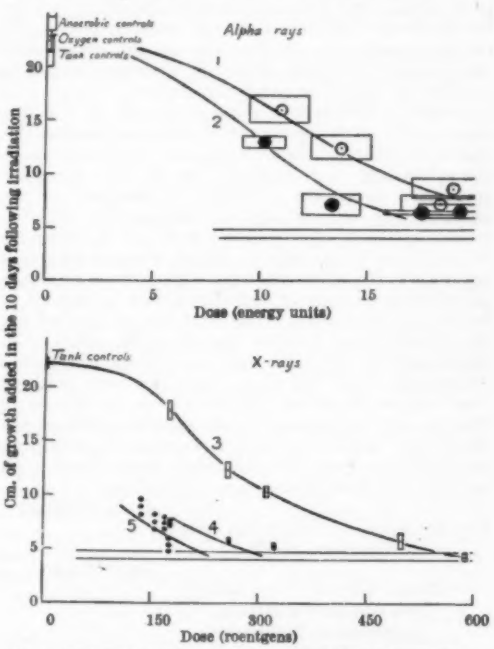


Fig. 1. Each point is the mean growth in ten days subsequent to irradiation of groups of 6 to 9 bean roots. The standard deviation is marked by a vertical line. 10 per cent of the alpha-ray dose has been considered the equivalent of a standard deviation. 1, Alpha-rays, zero oxygen concentration; 2, alpha-rays, 12 c.c. oxygen per litre; 3, X-rays, zero oxygen in the water; 4, X-rays, 6 c.c. oxygen per litre; 5, X-rays, 12 c.c. oxygen per litre. The horizontal lines at growths of 4 and 4·8 cm. illustrate the mean growth in length, with standard deviation, of a group of roots which all die as a result of irradiation, and represents the extension due to the elongation of existing cells, a process insensitive to radiation. All the curves, therefore, terminate in this zone

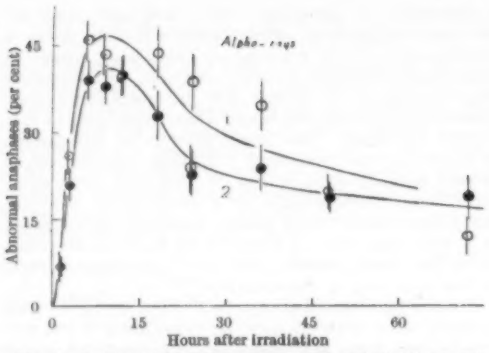


Fig. 2. 1, Dose, 7·7 energy units; oxygen content 12 c.c. per litre. 2, Dose, 8·0 energy units; oxygen content zero

tions when oxygen is present is somewhat greater than in its absence, but there can be no doubt that the increase due to oxygen is far less than that shown when X-rays are used (ref. 1, Fig. 2).

As before, we find a close correlation between the effects of different treatments on growth-rate and on the number of chromosome aberrations produced.

The effects of oxygen on the production of chromosome aberrations in *Vicia* by X- and alpha-radiations parallel its effects in promoting the decomposition of water by these radiations. Experiments summarized by Allsopp[4] and Lea[5] support the conclusion that pure oxygen-free water is not decomposed by X-rays, but if there is dissolved oxygen then hydrogen peroxide is produced. Alpha-rays, on the other hand, can produce hydrogen peroxide whether oxygen be present or not. Our results, therefore, suggest that hydrogen peroxide has some influence on the processes involved in chromosome structural change. We regard Mottram's[6] observation that cyanide increases the sensitivity of roots to X-rays as supporting this conclusion, since the inhibition of catalase or peroxidase may be expected to increase the effective concentration of hydrogen peroxide. It is, of course, impossible at this stage to decide whether hydrogen peroxide is the agent effecting chromosome breakage, or whether it merely influences the behaviour of broken chromosomes. The evidence of Kotval and Gray[7] that there is some spread of the effect of an alpha-particle may be held to favour the former alternative. On the other hand, we have evidence that oxygen increases the inhibition of mitosis by X-rays, and that while it increases the stickiness produced by X-rays it does not seem to affect the stickiness produced by alpha-rays, facts which might be held to favour the second alternative.

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## Total X-Irradiation of Rats under Urethane Anæsthesia

The therapeutic use of urethane in human leukæmias, discovered by Paterson, Ap Thomas, Haddow and Watkinson[1], has led many authors to study the action of urethane in comparison with that of X-rays. However, treatment of patients by X-rays *during* the period of urethane administration was mentioned for the first time by Vannotti[2] in two cases of myeloid leukæmia. More recently, Dustin and Simon[3] have obtained promising results in chronic myelogenous leukæmia by splenic irradiation concurrently with administration of urethane (2–3 gm. a day).

In 1925, Hawkins and Murphy[4] pointed out, in a footnote to their study of ethylurethane anæsthesia and acid-base equilibrium of the blood, that "rats under urethane anæsthesia irradiated by a dose of X-rays far below the lethal dose, died invariably between the 7th and 14th day". No technical detail was given, and these experiments do not seem to have been repeated. Recently, Paterson[5] found no cumulative action of urethane and X-rays either on fern spores or on fibroblast cultures.

In view of the potential clinical importance of the simultaneous application of urethane and X-rays, an attempt has been made to confirm the observations of Hawkins and Murphy.

To compare results of different experiments, the dose of radiation killing 50 per cent of the animals within 14 days (L.D. 50/14 days) was chosen in preference to that required to kill all the animals within the same time (absolute lethal dose, Ellinger[6]).

The rats used were of an albino strain and of weights ranging from 90 gm. to 140 gm. Each experiment was conducted with groups being irradiated under the same conditions. Rats for irradiation were placed in cardboard boxes divided into separate compartments. Preliminary experiments had shown an L.D. 50/14 days of 600 r., although it is evident that this value may vary with the strain, the age and the weight of the animals as well as with the conditions of the experiment. Following treatment, records were kept of the body-weight.

Irradiation, measured with an ionometer, was performed as follows: (1) rats irradiated with 500 r.: 200 kV. 8 mA.; focus-target, 60 cm.; filtration, 0·5 mm. copper + 1 mm. aluminium (rate, 29 r./min.); (2) rats irradiated with 600 r.: 200 kV. 10 mA.; focus-target, 80 cm.; filtration, 0·5 mm. copper + 1 mm. aluminium (rate, 20 r./min.). Rats in each group received the same dose.

Urethane was injected intraperitoneally, as in Hawkins and Murphy's report, using 1 c.c. of 10 per cent urethane solution per 100 gm. body-weight. Under these conditions, anæsthesia occurs very promptly. Irradiation of anæsthetized animals was made half an hour after urethane injection at the same time as the controls. Each rat was later kept in a separate cage.

Irradiation with 600 r. proved to be the L.D. 50/14 days for the control series.

Irradiation with a dose of 500 r. killed about 20 per cent of the animals within 14 days, both controls and anæsthetized. Thus, it could scarcely be said that a dose of X-rays far below the lethal dose kills all the rats under urethane anæsthesia, as 500 r. is within 20 per cent of the L.D. 50/14 days.

Irradiation with the L.D. 50 (600 r.), on the contrary, demonstrated a notable difference between the

control and anæsthetized animals: while 50 per cent of the controls died within 14 days, 90 per cent of the anæsthetized rats died within the same period. Hence, if there is any lethal cumulative effect or sensitization resulting from association of urethane anæsthesia with whole-body irradiation, it can only be observed within a range close to the L.D. 50/14 days. If, however, Hawkins and Murphy's test of mortality was the absolute lethal dose, the cumulative effect would have seemed important, since a dose of X-rays, two-thirds of the absolute lethal dose, would have produced in urethanized animals about the same effect as the absolute lethal dose in control rats.

To determine whether urethane anæsthesia sensitizes to X-rays, or acts cumulatively, experiments should be carried out by administering urethane after irradiation. Further research is proceeding along these lines.

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## A Contracture in Isolated Mammalian Muscle

RECENTLY, Goffart and Brown[1] have shown that the effectiveness of adrenaline in increasing the twitch tension of the isolated rat's diaphragm preparation is inversely proportional to the amount of potassium ion in the bath. In continuation of these experiments, I have been studying the responses of the rat's diaphragm preparation immersed in potassium-free Tyrode's solution.

Administration of adrenaline ($1:10^5$–$1:10^6$) causes the usual increase in twitch tension, but this may be followed by a progressive delay in relaxation. The delayed relaxation of the muscle shows itself in the first place by a reduction of the 'overthrow' of the light spring-loaded lever used for recording. The 'overthrow' is usually increased during the potentiation of twitch tension, which is the first effect of adrenaline. If the fluid in the bath is left unchanged, the 'overthrow' is seen gradually to decline, until, some 20 min. after giving adrenaline, relaxation is clearly diphasic, a rapid initial phase being followed by a slow return of the lever to the base line. The first phase of relaxation then becomes shorter, and the slow phase starts nearer the peak of the contraction curve. The delayed relaxation is not accompanied by conducted repetitive action potentials, and appears, therefore, to be of the nature of a true contracture.

The only observed changes in action potential were similar to those described by Brown, Bülbring and Burns[2]. The contracture can be produced in fully curarized muscle stimulated directly and appears, therefore, to be of purely muscular origin. It is increased by increasing the calcium chloride content of the bath fluid from the normal 0·02 per cent to 0·06 per cent, and is at first increased and then suppressed by addition of potassium chloride to give a final concentration of 0·04 per cent. Although the contracture can be generally produced by addition of adrenaline, the latter is not invariably necessary, since prolonged stimulation of a preparation in potassium-free Tyrode's solution may produce it; adrenaline appears to accelerate the process. The contracture is increased by using lower frequencies of stimulation (< 1 in 10 sec.) and may be suppressed by increasing the frequency of stimulation from 1 in 10 sec. to 1 per sec. High concentrations of atropine and quinine ($1:10^4$) eventually suppress the contracture, and it is also very sensitive to changes in temperature: cooling by 0·5° C. may increase it, and warming the preparation by 1° C. may remove it.

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## Utilization of Folic Acid Conjugate in Man

Heinle and Welch[1] have already made some observations on the utilization of folic acid conjugate. They did not observe formation of free folic acid from pteroyl-hepta-glutamic acid after incubation of the latter product with normal gastric or duodenal juice.

We have repeated this investigation and have found that the hepta conjugate is altered by normal gastric juice, although no free folic acid could be demonstrated (Buyze and Engel[2]).

If the incubation product of gastric juice on folic acid conjugate from yeast is incubated with rat liver conjugase prepared according to Mims, Totter and Day[3], no free folic acid was formed. This was not due to conjugase inhibitors present in gastric juice or yeast extract, as has been demonstrated[2]. This alteration of folic acid hepta conjugate into another 'conjugate' by normal gastric juice was not brought about by gastric juice of pernicious anæmia patients. The gastric juice of a sprue patient behaved like a normal human gastric juice in this respect. Normal duodenal juice was not active against pteroyl-hepta-glutamic acid or the conjugate formed by the gastric juice.

Olson, Fager, Burris and Elvehjem[4] have demonstrated that pteroyl-glutamic acid was present in rat liver not only in the form of its hepta conjugate but also in another conjugated form. It was possible to obtain free pteroyl-glutamic acid from the latter by incubation with liver homogenate. It appeared that from the gastric juice incubation product also free folic acid could be obtained by incubation with rat liver homogenate at *p*H 7.

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## Antigenic Activity of Myosin and Actin

To our knowledge, the immunological behaviour of contractile muscle proteins has not been investigated. We immunized three rabbits and three dogs with rabbit's myosin prepared by the method of Szent-Györgyi[1]. We used intraperitoneal injections of 2·5 per cent myosin solution, the myosin being dissolved in 0·4 *M* potassium chloride. The animals received 0·5 gm. of myosin in increasing doses during seventeen days; they lost no weight during the treatment. With these antisera, precipitation tests were performed with the following antigens: rabbit's myosin, *F*-actin, *G*-actin, *F*-actomyosin and normal rabbit serum. The same tests carried out before treatment with normal sera of animals afterwards immunized served as controls. The results are seen in Table 1.

Table 1

| | Rabbits' | | | | |
|---|---|---|---|---|---|
| | Myosin | *F*-actin | *G*-actin | *F*-actomyosin | Serum protein |
| Rabbit 1 | — | — | — | — | — |
| ,, 2 | — | — | — | — | — |
| ,, 3 | — | — | — | — | — |
| Dog 1 | +++ 1: 500 | — | — | ++1 : 125 | — |
| ,, 2 | ± 1: 4000<br>+ 1: 2000<br>++ 1: 1000<br>+++ 1: 500 | — | — | ++1 : 1000 | — |
| ,, 3 | — | — | — | — | — |

Rabbits' myosin injected into rabbits intraperitoneally did not incite antibody formation; this indicates that the presence of myosin in the blood of the same species does not lead to the production of *iso*antibodies. We succeeded in obtaining myosin antisera from two of the immunized dogs. The immune sera did not react with *F*- and *G*-actin; this indicates that the myosin prepared by the method of Szent-Györgyi is free from actin. *F*-actomyosin reacts with the antisera for myosin; this may be explained either by the presence of free polar groups of the myosin molecule in the actomyosin, or by the presence of free unchanged myosin molecules in the antigen solution after the linkage between actin and myosin. The probability of the latter explanation seems to be corroborated by the lower precipitation titre of myosin antisera with actomyosin and by the circumstance that—according to Szent-Györgyi—actomyosin does not represent a stoichiometrically definable compound.

In further experiments, we used *G*-actin from rabbits' muscle prepared by the method of Straub[1]. Three rabbits and three dogs were immunized with 0·3–0·6 per cent water solutions of *G*-actin. The animals received intraperitoneally 120 mgm. actin in increasing doses during seventeen days. Three weeks later, precipitation tests were made using the same antigens as in the previous experiment.

Table 2

| | | Rabbits' | | | |
|---|---|---|---|---|---|
| Rabbit | Myosin | *F*-actin | *G*-actin | *F*-actomyosin | Serum protein |
| 1 | — | — | — | — | — |
| 2 | — | +1 : 500 | +1 : 500 | +1 : 500 | |
| | | ++1 : 250 | ++1 : 250 | ++1 : 250 | — |
| 3 | — | +1 : 2000 | +1 : 2000 | +1 : 1000 | — |
| Dog | | | | | |
| 1 | — | +1 : 2000 | +1 : 2000 | +1 : 2000 | — |
| 2 | — | — | — | — | — |
| 3 | — | ++1 : 250 | ++1 : 250 | ++1 : 250 | — |

The sera of two immunized rabbits precipitated rabbits' actomyosin with a relatively high titre. It follows that rabbits' actin administered to rabbits parenterally incites antibody formation, that is to say, it represents an *iso*antigenic, organ-specific protein. The antisera of dogs and rabbits reacted equally with *F*-actin; this indicates that the activation of actin did not result in any changes in the antigenic (chemical) structure of *G*-actin. Antisera for myosin and actin behave similarly towards actomyosin.

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## Determination of Adrenaline in Blood Plasma by the Fluorescence Method

Among chemical methods for determining adrenaline in blood the fluorescence method seems superior[1–6]. It has been used in two basically different versions: either blood plasma[3,4] or a dialysate of hæmolysed blood[1,5,6] has been analysed. It is noteworthy that the first method gives much higher values than the second.

Theoretical objections may be raised against adrenaline determinations on dialysates of hæmolysed blood, since the supposed state of equilibrium on both sides of the membrane after four hours of dialysis is assumed, based on the fact that the adrenaline concentration in the outer liquid attains its maximum after four hours. As adrenaline cannot be determined in hæmolysed blood, simultaneous control determinations in the impermeate are impossible. Also the eventuality that the adrenaline might be bound to the protein and, therefore, hindered from dialysing through the membrane has been overlooked. Keeping these factors in mind, we have found occasion to compare the two methods more closely.

In so doing we used a modification of Lehmann's and Michaelis' method[3,7], which has the essential advantage that, by using a Beckmann spectrophotometer with an accessory fluorescence set, readings are easier to take and less subjective. This method yielded reproducible results; determinations on plasma with known adrenaline contents and on plasma with a known quantity of adrenaline added gave results closely corresponding to calculated ones.

Determinations were made on plasma and blood by the method of dialysis, and directly on plasma. This showed that the dialysis method yields values in the dialysate which closely correspond to those obtained by other authors in tests on hæmolysed blood, namely, approximately 0·07 μgm./ml. A small decrease was noted in the plasma impermeate which, in this case, may be analysed in parallel to the dialysate. The concentration was, however, of the same magnitude as that found in analysing untreated plasma, namely, 1–3 μgm./ml. Therefore only some few per cent of the adrenaline had passed through the membrane. The same low values in the dialysate were obtained in testing hæmolysed blood. Analogous tests on aqueous solutions of adrenaline showed the outer and inner liquids to be in equilibrium after four hours.

This observation leads us to conclude that the two modifications of the fluorescence method give incompatible results. In one case, free dialysable adrenaline is determined, whereas in the other total adrenaline contents, including both free and protein-bound adrenaline. The existence of both these forms of adrenaline is probably of the greatest importance for the biological activity of this substance in the tissues.

A more comprehensive report will be published in due course.

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## Bilateral Asymmetry Shown by the Metachronal Waves in Protochordate Gill Slits

MULLER[1] stated that metachronal waves travelled round the gill slits of *Amphioxus* "am vordern Rande aufwarts, am hinten abwarts"; but he figured them moving in the opposite direction on the left side of the pharynx. Franz[2] did not clear up the contradiction, though he, too, noted and figured the metachronal waves. Fedele[3], in a figure of the gonozoid of *Doliolum mulleri*, indicated by arrows the movement of the metachronal waves around the stigmata. The movement appeared anti-clockwise on both sides, seen from outside the pharynx. McGinitie[4], examining the pharynx of *Ascidia californica* through the transparent test, also noted that the motion was anticlockwise. Since he did not state from which side of the animal this observation was made, it might be inferred that the direction appeared the same from both sides; but McGinitie did not specifically affirm this nor did he direct attention to the functional asymmetry implied. If the animal were bilaterally symmetrical in this respect, the movement would appear anticlockwise from one side but clockwise from the other, like the wheels of a car in motion.

During work on the development of *Saccoglossus*, carried out in collaboration with Mr. C. Burden Jones, University College of North Wales, Bangor, it was noted that the metachronal waves in the primary gill pores moved anticlockwise on both sides, as seen from the exterior. In adult *Saccoglossus*, as in *Amphioxus*, the shape of the gill slits is greatly modified by the down-growth of the tongue bars, yet the movement of the waves is uninterrupted and their direction is the same as in the larva. It was observed by opening the pharynx in the mid-ventral line, viewing the gill slits from within and waiting for the cilia to resume activity. From this point of view the motion appeared clockwise. The pharynx in young specimens of *Ciona intestinalis* and *Ascidia aspersa* was examined through the transparent test. The waves which moved around each stigma appeared anticlockwise on both sides of these animals. Mr. D. P. Wilson kindly informed us that in *Amphioxus* the direction of the metachronal waves is clearly anticlockwise on both sides, seen through the transparent body wall. Muller's figure is therefore correct, but his statement, quoted above, applies only to the gill slits of the right side.

Hitherto, *Amphioxus* has provided the only strong link between the Hemichordata and Urochordata in respect of the structure of the pharynx, so it is noteworthy to find, in the activity of the lateral cilia, a point of detail common to all three Protochordate groups. A similar asymmetry is shown by the velar cilia in Gastropod larvæ having a bilobed velum, but this is only to be expected, for the lobes are the parts of a single velum around which the waves travel uninterruptedly. There is no reason to believe that gill slits have been derived from unpaired structures, and the significance of the asymmetry in Protochordates is much more obscure.

According to Fedele[3], the activity of the lateral cilia in *Doliolum* imparts a rotation to the current of water which passes through each stigma. This causes the column of water within the pharynx to rotate, forming a vortex which plays a part in directing into the narrow entrance to the œsophagus the mucous strings by which the food is collected. It appears, therefore, that in this form the asymmetry in the gill slits may indirectly assist the feeding mechanism. In *Salpa*, however, the numerous feeding strings are sucked into a similar vortex produced by the ciliary activity of the œsophagus and intestine[5]. To judge from Fedele's account, this mechanism, which is essentially the same as that in *Doliolum*, operates in *Salpa* without the aid of the functional asymmetry under review here. It is therefore doubtful whether this asymmetry is of great importance even in *Doliolum*. Outside the Thaliacea, it appears to be entirely non-adaptive, yet its general occurrence suggests that it was present in ancestral Chordates. The following considerations suggest a possible direction in which the cause of its origin might be sought.

In the larva of *Saccoglossus* and in the *Tornaria* there is a belt of large cilia, the telotroch, encircling the body immediately behind the primary gill slits. Well-marked metachronal waves travel around it anticlockwise, as seen from the animal pole[6], that is, up the left side of the body and down the right. Soon after the first gill slits appear, the telotroch starts to regress, but in *Ptychodera bahamensis* it can be distinguished for some time after metamorphosis, and it is carried backwards as the trunk elongates so that each of the early gill slits appears in turn immediately in front of it[7]. The first gill slits, therefore, develop in the immediate proximity of a strong ciliary field which is continuously active. It is possible that the bilateral asymmetry in the ciliary mechanism of the gill slits is associated in some way with that of the telotroch. As they develop, the posterior borders of the gill slits immediately adjoin the telotroch. The metachronal waves on these posterior borders come to move in the same direction as did those of the telotroch, upwards on the left side, downwards on the right.

The activity of the telotroch causes the larvæ of *Enteropneusta* to rotate about the longitudinal axis in a clockwise direction viewed from the animal pole[6]. The rotation and the movement of the metachronal waves are associated phenomena. An exactly similar rotation has been observed in the early larva of *Amphioxus*[8,9], a fact which suggests the existence there of a similarly orientated ciliary field. This, in

turn, suggests that such a field may have been present in the larvæ of ancestral Chordates.

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## A Simple Medium for Cultivation of *V. choleræ*

THE nutritional requirements of *V. choleræ* have been studied with the object of developing a simple medium capable of giving a massive growth of the organism which could be used directly as a vaccine. The investigations were on the lines followed by Linton and Jennings[1–3]. It was found possible to obtain concentrations as high as 14,000 million organisms per ml. of *Inaba* or *Ogawa* strains of *V. choleræ* maintained at this Institute by the following method.

A 2-litre flask containing the following was autoclaved: sodium chloride, 8 gm.; potassium chloride, 0·2 gm.; calcium chloride, 0·4 gm.; magnesium chloride, 0·2 gm.; sodium dihydrogen phosphate, 0·06 gm.; ammonium sulphate, 5 gm.; magnesium sulphate, 0·1 gm.; and distilled water, 1,000 ml. To this was added 30 ml. of 33⅓ per cent glucose solution and 27·5 ml. of 0·1 per cent *l*-cystine. The latter was made by dissolving 100 mgm. of *l*-cystine in 30 ml. of *N*/10 sodium hydroxide, which was then made up to 100 ml. with distilled water. To the mixture was added 5 ml. of a 5 per cent solution of 'Marmite' paste in distilled water. The solutions of glucose, *l*-cystine and 'Marmite' were sterilized by steaming. 11 gm. of sodium bicarbonate powder, sterilized by autoclaving, was added to the mixture and shaken until all the bicarbonate dissolved. The final *p*H of the medium was 8·8.

About 60 ml. of the medium was removed for purposes of subpassage, etc., and the remaining 1,000 ml. inoculated with 10,000 million organisms of *V. choleræ*; either *Inaba* or *Ogawa* strains or a mixture of 5,000 million organisms of each were used. The best results were obtained with an inoculum of an eight to twelve hours culture of the organism which had undergone at least six serial passages in the above medium and become adapted to it. The flask was incubated at 37° C. At the end of 10, 16 and 24 hr., 12 ml. of glucose solution and 9 gm. of sterile sodium bicarbonate were added to the cultures, shaken well and returned to the incubator. With the above method it was possible to obtain concentrations of 12,000–14,000 million organisms per ml. of both the strains at the end of 30 hours incubation.

The ammonium sulphate in the medium served as a buffer. Without the addition of ammonium sulphate, growth started earlier but ceased at the end of 10 hours when the *p*H reached 6·7. By periodic neutralization of the medium with sodium bicarbonate, it was possible to maintain the *p*H in the vicinity of 8, with a marked increase in the growth of vibrios.

The salts used in the medium had a beneficial effect on the growth of *V. choleræ*. Of the several amino-acids tried, *l*-cystine had a beneficial effect. Addition of tryptophan was necessary for the cultures to give the cholera red reaction. 'Marmite' paste had a marked growth-promoting effect on the organism. Substitution of 'Marmite' with thiamine hydrochloride, nicotinic acid, pyridoxine hydrochloride, calcium pantothenate, riboflavin, biotin and yeast nucleic acid, singly or in combination, did not give equally good results.

Cultures need not be shaken periodically except while adding extra quantities of glucose and sodium bicarbonate. Periodic shaking of the cultures or bubbling of air or oxygen through them did not improve the growth. Bubbling of carbon dioxide had a deleterious effect on the cultures.

Concentrations of 12,000–14,000 million organisms per ml. were obtained when the organism was grown in 3-litre quantities in a 4-litre flask.

The above medium, without the addition of ammonium sulphate and magnesium sulphate and adjusted to *p*H 8·8 with sodium bicarbonate, was found to be better than Dunham's peptone water for the isolation of *V. choleræ*.

Cultures containing 14,000 million organisms per ml. were rendered sterile by the addition of 0·5 per cent phenol and incubation at 37° C. for 24 hours. The antigenic value of these cultures is under investigation.

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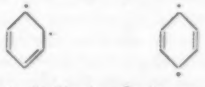
## Reactive Structures of Hydrocarbons and Catalytic Hydrogenation

A CARBON atom in its ground-state has the structure $1s^2 2s^2 2p^2$, $^3P$. In such a state, the spins of the *p* electrons are coupled to unity. Penney[1] has shown that in order to obtain a divalent carbon atom, that is, one in which the spins are free, a mixture of the $^1D$ and $^3P$ states in the ratio 1 : 3 must be considered. The energy of attaining such a structure is the promotional energy. Such a structure has no independent existence, but arises from a perturbation of the carbon atom by the atom with which it is going to form a bond.

The concept may be extended to ethylene and to conjugated and aromatic systems. A reactive structure may be thought of as having two electrons with free spin at the given positions. Thus, for benzene there are two possibilities:



where the dots indicate electrons the spins of which are essentially free. The reaction structure may be thought of as a combination of singlet and triplet in the ratio 1 : 3. For any position in any molecule, that is, for any reactive structure, the energy may then be written in the form:

$$E_r = (1{\cdot}5 + n_r - n_p)\alpha, \qquad (1)$$

where $\alpha$ is the valence-bond exchange integral and $n_r$ and $n_p$ are the coefficients of $\alpha$ in the expression for the resonance energies of the reactant and product molecules respectively.

It would appear likely that the concept of the reactive structure might prove useful in a discussion of homolytic bicentric reactions between a series of molecules and a common reaction partner. Catalytic hydrogenation would appear to be a reasonable reaction to choose "since all the observed facts are in harmony with the conception that the catalyst in hydrogenation combines with both the hydrogen acceptor and the hydrogen"[2].

The main feature of catalytic hydrogenation may be explained on the basis of the reactive structure. The ease of hydrogenation of an isolated double bond follows at once from the low $E_r$ for such a reaction ($n_r = n_p = 0$). On the other hand, the resistance of benzene to catalytic hydrogenation can be explained in terms of the large value of $E_r$, due to $n_r$ being much greater than $n_p$. However, in the event of two atoms of hydrogen being added, $E_r$ for the further addition becomes considerably decreased, and this is evidenced by the tendency for complete reduction of a benzene ring in a polycyclic compound. In general, the difficulty of reduction of conjugated systems relative to an isolated double bond is explicable in terms of $n_r$ being greater than $n_p$, leading to large values of $E_r$. Another example of the use of the concept is afforded by the relative indifference to the position of addition in the case of butadiene, for in this case $E_r$ is the same for both $CH_2{=}CH{-}CH{-}CH_2$ and $CH_2{-}CH{=}CH{-}CH_2$.

The concept of the reactive structure lends theoretical support to the assumption used by Pauling and Sherman[3] in their discussion of conjugated systems. These authors assumed that the product will be formed the more readily the greater its thermodynamic stability. This hypothesis was used in a discussion of the position of hydrogenation within a given molecule, and follows directly from (1). The purpose of the present note is to provide a basis for a discussion of relative ease of hydrogenation.

A fuller discussion of this subject will be presented elsewhere in due course.

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## Estimation of Polymer Distribution on the Basis of Differences between the Average Molecular Weights of Different Order

IT is well known that the magnitude of the difference between the number and weight average molecular weight ($M_n$ and $M_w$) in a polymer affords an indication of the degree of polydispersity. In order to obtain a numerical measure of the spread of molecular weights, and to reconstruct the distribution, the assumption is often made—though admissible only under certain conditions—that the distribution function is that of the log normal law[1-3], where the ratio between averages (the $r$th roots of the $r$th moments about zero) of successive order is an exponential function of the logarithm of the geometric standard deviation, which is equal to the standard deviation of the logarithmic distribution.

It has, however, so far escaped observation that from a knowledge of $M_n$ and $M_w$ the standard deviation of the molecular weights can be calculated directly and exactly without any assumption whatsoever about the distribution law.

Defining $M_n$ as

$$M_n = \frac{\Sigma M_i n_i}{\Sigma n_i},$$

as obtained, for example, by the osmotic pressure method; and $M_w$ as

$$M_w = \frac{\Sigma M_i g_i}{\Sigma g_i} = \frac{\Sigma M_i^2 n_i}{\Sigma M_i n_i},$$

as obtained, for example, by the light scattering method, where $n_i$, $g_i$ are the frequencies and weights, respectively, of the molecular species $M_i$, we form the product

$$M_n M_w = \frac{\Sigma M_i n_i}{\Sigma n_i} \times \frac{\Sigma M_i^2 n_i}{\Sigma M_i n_i} = \frac{\Sigma M_i^2 n_i}{\Sigma n_i}.$$

Since

$$\sigma_n = \sqrt{\frac{\Sigma M_i^2 n_i}{\Sigma n_i} - \left(\frac{\Sigma M_i n_i}{\Sigma n_i}\right)^2},$$

we have at once for the standard deviation of the number distribution:

$$\sigma_n = \sqrt{M_n M_w - M_n^2}.$$

Similarly, if in addition to $M_w$, $M_z$ is defined by

$$M_z = \frac{\Sigma M_i^2 g_i}{\Sigma M_i g_i} = \frac{\Sigma M_i^3 n_i}{\Sigma M_i^2 n_i},$$

as obtained, for example, by the sedimentation equilibrium method (if the concentration gradient is observed by the refractive index method), we form again the product

$$M_w M_z = \frac{\Sigma M_i g_i}{\Sigma g_i} \times \frac{\Sigma M_i^2 g_i}{\Sigma M_i g_i} = \frac{\Sigma M_i^2 g_i}{\Sigma g_i},$$

and have for the standard deviation of the weight distribution

$$\sigma_g = \sqrt{M_w M_z - M_w^2}.$$

Knowing the mean and the standard deviation in either number or weight distribution of molecular weights, we are in a position to obtain a conservative estimate of the whole distribution by using the so-called Tchebycheff inequality[4]. According to that relation, the proportion of molecules with molecular weights differing from the mean weight by an amount not exceeding $\pm t$ times the standard deviation is, at least, $1 - 1/t^2$. By substituting arbitrary values for $t$ ($5 > t > 1$), and subtracting the proportion for the smaller $t$ from that for the next higher one, we obtain the relative frequencies (number distribution) or the weight fractions (weight distribution) of the molecular weight species at the specified distances from the mean.

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July 5.

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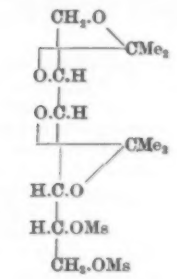
## Reaction of Vicinal Dimesyl Compounds with Sodium Iodide, and its Application to the Interconversion of Hexitols

THE recent paper of Karrer and Davis[1] prompts us to report some work of a similar nature, on which we have been recently engaged.

Previous investigators[2-4] have shown that treatment of a compound containing two or more vicinal tosyloxy groups, with sodium iodide, leads to the elimination of all these groups, whether primary or secondary, with formation of an unsaturated compound, and the liberation of iodine. We have been using this type of reaction mainly for the preparation of intermediates for the synthesis of polyhydroxy dithiols (cf. Evans and Owen[5]), and have found that it is equally applicable to mesyl (methanesulphonyl) compounds.



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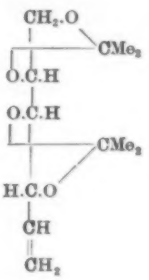

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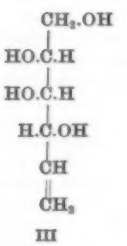

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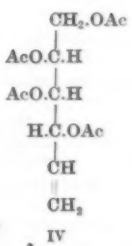

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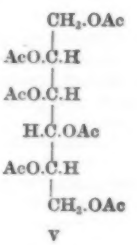

V

(Ms = $CH_3.SO_2$—)

Treatment of 5 : 6-dimesyl 1 : 2-3 : 4-diacetone D-mannitol (I) (m.p. 117·5–120°, $[\alpha]_D^{20°}$ + 25·1°; all rotations in this communication were determined in chloroform solution unless otherwise stated) with sodium iodide in acetone solution at 100° gave a 65·5 per cent yield of 1 : 2-3 : 4-diacetone 5 : 6-mannitoleen (II), a colourless liquid, b.p. 41°/0·1 mm., $n_D^{23°}$ 1·4401, $[\alpha]_D^{21°}$ — 5·49° (found: C, 63·4; H, 8·6. $C_{12}H_{20}O_4$ requires C, 63·1; H, 8·8 per cent), together with a small amount of 5 : 6-mannitoleen (III), (Karrer's D-*arabo*-3 : 4 : 5 : 6-tetrahydroxyhex-1-ene), m.p. 147–149°, $[\alpha]_D^{20°}$ + 30·9° (water). Hydrolysis of the diacetone compound in the usual way gave a 69 per cent yield of 5 : 6-mannitoleen, [tetra-acetate (IV) m.p. 80–81°, $[\alpha]_D^{21·5°}$ + 49·4°]. Karrer and Davis[1], who employed 5 : 6-ditosyl 1 : 2-3 : 4-diacetone mannitol as starting material in a similar reaction, failed to isolate diacetone mannitoleen, and obtained only mannitoleen in 26 per cent yield.

Similar treatment of 5 : 6-dimesyl 1 : 3-2 : 4-diethylidene sorbitol with sodium iodide gave a theoretical yield of 1 : 3-2 : 4-diethylidene 5 : 6-sorbitoleen, m.p. 122–123°, $[\alpha]_D^{21°}$ — 21·6° (found: C, 60·4; H, 7·9. $C_{10}H_{16}O_4$ requires C, 60·1; H, 8·1 per cent), acid hydrolysis of which afforded 5 : 6-sorbitoleen (97 per cent yield), a colourless syrup, b.p. 100–130° (bath)/$10^{-4}$ mm., $n_D^{18°}$ 1·5068, $[\alpha]_D^{18°}$ + 19·8° (water) (found: C, 48·5; H, 8·3. $C_6H_{12}O_4$ requires C, 48·6; H, 8·2 per cent) (tetra-acetate, m.p. 57–58·5°, $[\alpha]_D^{22°}$ — 13·6°). 5 : 6-Ditosyl 1 : 3-2 : 4-diethylidene sorbitol gave the same products, though in poorer yield.

Incidental to the main work, the following new method for the interconversion of hexitols has been evolved. Treatment of 5 : 6-mannitoleen tetra-acetate with hypobromous acid, according to the method of Raphael[6], and reaction of the crude bromohydrin with a mixture of acetic acid, acetic anhydride, and fused sodium acetate, yielded D-sorbitol hexa-acetate (V), m.p. and mixed m.p. 97–98°, $[\alpha]_D^{20°}$ + 9·04°. No mannitol hexa-acetate, the other possible product, could be detected. Similarly, from sorbitoleen tetra-acetate, L-iditol hexa-acetate, m.p. 119–120°, $[\alpha]_D^{22°}$ — 26·8°, was obtained, no sorbitol hexa-acetate being encountered.

Full details will be published elsewhere. One of us (P. B.) desires to thank the Department of Scientific and Industrial Research for a maintenance grant.

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Nov. 8.

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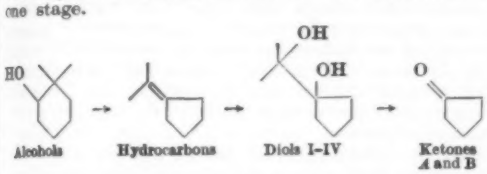
## Position of the Hydroxyl Group in Lanosterol

DEHYDRATION of alcohols of the lanosterol series to the corresponding hydrocarbons has recently been reported by us[1], when the action of both phosphorus pentachloride and phosphorus oxychloride was described. Dihydroagnosterol and dihydrolanosterol, when treated with phosphorus pentachloride, gave *iso*-agnostadiene ('iso-γ-lanostatriene'), $C_{26}H_{42}$, and *iso*-lanostadiene, $C_{30}H_{50}$, respectively, and hydrocarbons isomeric with the above dehydration products were obtained with phosphorus oxychloride. We expressed the opinion, based on a consideration of analogous cases in triterpene chemistry, that the phosphorus pentachloride dehydration involved a retropinacoline rearrangement accompanied by a contraction of the terminal ring *A* of lanosterol, and stated that experiments to confirm this view were in progress. In the meantime, Ruzicka *et al.*[2], following our method of preparation, have reported the results of oxidation experiments on the dehydration product from dihydrolanosterol, and afforded evidence in support of the reaction mechanism suggested above, establishing at the same time the position of the secondary hydroxyl group in lanosterol. The continuation of our work has involved the study of the same series of reactions applied both to *iso*-agnostadiene and *iso*-lanostadiene, and in view of Ruzicka's publication, we now present a brief summary of our results.

*Iso*-agnostadiene, when oxidized with osmium tetroxide, gave a mixture of two diols of formula $C_{30}H_{50}O_2$, which differ only in the steric configuration of their hydroxyl groups and were separated by chromatographic analysis. Both ***diol I***, $C_{30}H_{50}O_2$, m.p. 140–142° (found: C, 80·97; H, 11·47 per cent; $C_{30}H_{50}O_2$ requires: C, 81·45; H, 11·31 per cent), and ***diol II***, $C_{30}H_{50}O_2$, m.p. 128–130° (found: C, 80·68; H, 11·20 per cent), gave, on oxidation with lead tetra-acetate, the ***ketone A***, $C_{27}H_{42}O$, m.p. 85–87° (found: C, 84·51; H, 10·59 per cent; $C_{27}H_{42}O$ requires: C, 84·82; H, 10·99 per cent), while acetone (isolated as the 2-4-dinitrophenylhydrazone) was obtained in almost theoretical yields. The same series of reactions was carried out with *iso*-lanostadiene, yielding diols III and IV, $C_{30}H_{52}O_2$, and the corresponding ketone *B*, $C_{27}H_{44}O$ (Ruzicka's substance V), the constants of which were in essential agreement with the values given by Ruzicka *et al.* (*loc. cit.*). *Iso*-agnostadiene and *iso*-lanostadiene were further subjected to ozonolysis, when acetone and the respective ketones *A* and *B* were obtained in one stage.




The loss of acetone with formation of a ketone, when the diols obtained by osmium tetroxide oxidation of *iso*-agnostadiene and *iso*-lanostadiene are further oxidized with lead tetra-acetate, indicates the presence of a terminal *iso*-propylidene grouping in these hydrocarbons. The retropinacoline rearrangement occurring when triterpenoid alcohols are dehydrated with phosphorus pentachloride[3] thus takes place also in the analogous formation of *iso*-agnostadiene and *iso*-lanostadiene, and establishes the location of the hydroxyl group in the lanosterol molecule in the terminal ring, in a position adjacent to the *gem.*-dimethyl group. A detailed account of this work will appear elsewhere in due course.

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July 26.

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## Specific Solvents for Lower Rank Bituminous Coals

In the course of recent studies of the effect of solvents on bituminous coals, a number of solvents have been found to share with pyridine and with ethylene diamine[1] the property of extracting a considerable quantity of coal at atmospheric temperatures. The difference between these and other solvents is sufficiently marked to warrant their designation as specific solvents for coal. The main types of specific solvent appear to be: (1) aliphatic compounds containing at least one primary amino group; (2) aromatic compounds containing at least one primary amino group attached to an aliphatic side-chain; (3) certain heterocyclic nitrogen compounds, such as pyridine, piperidine, morpholine (but not piperazine or pyrrole).

The specificity of the interaction is emphasized when piperazine and dioxan (inactive) are compared with morpholine and piperidine (active). Slow diffusion of the solvent through the solid often tends to obscure the issue, especially with solvents of high viscosity.

Sufficient solvents have not yet been tested to enable a hypothesis to be formulated. It is already evident that the effect is complex, depending probably upon a suitable combination of at least two properties, one promoting swelling and loosening of the structure, the other solution. At room temperature many compounds (for example, phosphorus oxychloride and ethylene oxide) cause pronounced swelling, but little or no solution; the reverse combination has not been observed. The apparent dependence of solution upon swelling has also been noted by Losikov[2]; a general connexion between the two phenomena, as regards different ranks of coal, was found by several earlier investigators[3].

It is of interest to consider the extraction[1] of lower rank coals with ethylene diamine at its boiling point in the light of Kiebler's generalization[4] that the percentage of bituminous coals extracted by a number of different solvents at a given temperature is correlated with the internal pressure of the solvent better than with any other physical property. There are many conspicuous exceptions to this rule (for example, water), which give too low a yield. Direct comparison is not possible since Kiebler's results are expressed in the form of four correlation lines representing experiments at 150° C., 200° C., 150° C. and 300° C. respectively, whereas ethylene diamine boils at about 117° C. However, if points taken from Kiebler's lines (extended where necessary) at the appropriate internal pressure (117 cal./c.c.) are plotted against temperature, and the resulting curve is extended to 117° C., the expected yield appears to be less than one-third of that obtained experimentally.

Pyridine, which extracts coal at room temperature, and aniline, which is effective only at higher temperatures, both occupy similar relative positions (above the average) in Kiebler's correlation. The differences between these classes probably tend to decrease at higher temperatures. But it seems reasonable to treat the specific solvents (such as ethylene diamine) as a class distinct from those of intermediate solvent power, and from those which are exceptionally inactive, like water.

It is clear that whereas, in such solvents as water and the glycols, hydrogen bonds linking hydroxyl groups contribute largely to the latent heat of vaporization (and therefore to the internal pressure), their presence does not impart the power of functioning as a solvent for coal.

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# CHEMOTHERAPY OF FILARIASIS

WORKERS engaged in the search of a cure for filarioid infestations in man and animals will welcome the publication* of a symposium of fifteen papers by thirty-eight contributors who attended a conference on "The Chemotherapy of Filariasis" under the auspices of the Section of Biology of the New York Academy of Sciences on October 17 and 18, 1947. The term 'filariasis' in this publication signifies an infestation with a member of the nematode super-family Filarioidea. The use of this term recalls the days when the nematodes recovered from the lymphatic, circulatory or connective tissues or from the serous cavities of man and the lower vertebrates were all grouped in the genus *Filaria*, Mueller, 1787. Purists in medical and veterinary sciences, adopting the present-day classifications of taxonomy in biology, may maintain rightly that the term 'filariasis' should no longer be employed to indicate all infestations due to members of the genera *Onchocerca*, *Loa*, *Wuchereria*, *Acanthocheilonema*, *Mansonella*, *Dirofilaria*, etc. The use of the terms 'onchocerciasis', 'loaiasis', etc., indicates specifically the genera involved.

L. T. Coggeshall deals briefly with the history of filariasis due to *W. bancrofti* in the United States, and discusses symptomatology, pathology, immunology, prophylaxis and control. He includes remarks on loaiasis, onchocerciasis and dracontiasis. Filarioid infestations are, as a rule, chronic in character. Clinical manifestations may not become evident for years. There is still controversy as to whether the induration of the tissues in cases of elephantiasis, induced by *W. bancrofti* and occasionally by *O. volvulus*, is not due to secondary bacterial invasion. Coggeshall observes that the pathological changes are not typical of streptococcal infections and that they do not respond to agents which have a specific effect on the streptococcus.

No marked degree of immunity against further re-infection has been detected in individuals already infested, and cases of the same individual being infested with two or more members of the super-family are not uncommon. Coggeshall estimates that up to two million human beings are infested with worms of this group, while other American workers claim that the victims number twenty million. The incidence in domestic animals (horse, ox, sheep, goat, pig, camel, dog, cat, etc.) is high and widespread even in temperate climates. There is no doubt that the efficiency, productivity and welfare of many countries in the tropics and subtropics are seriously impaired by filarioid infestations in man and his livestock.

The low mortality associated with these forms of helminthiasis has rendered the general public indifferent to the sufferings of the afflicted. In the endemic regions, the efforts of the public health authorities to control and eradicate these maladies by prophylactic measures are handicapped by many difficulties, and Coggeshall hopes that the discovery of an effective chemotherapeutic agent would facilitate the elimination of infections from the endemic areas.

The general experimental methods used in studying 'filaricides' are discussed by R. I. Hewitt. The cotton rat (*Sigmodon hispidus*), naturally infected with a filariid, *Litomosoides carinii*, has been found a most suitable experimental animal for testing the efficiency of 'filaricides'. Dogs, infected with the blood filariid, *Dirofilaria immitis*, are used for comparative and confirmative work; but they are considered too large for use in ordinary routine work. The estimation of the efficiency of a 'filaricide' against the species parasitizing the cotton rat is based on destruction of the microfilariæ and its action on the adult worms. Hewitt attributes the disappearance of the microfilariæ in infected cotton rats to the death of the adult worms and not to a direct action upon the microfilariæ. He experimented with various piperazine compounds and admits that the use of controlled quantitative infestations has many advantages over naturally established infections; he considers that the relationship between drug dosage and the intensity of infestation can be gauged best in standardized infections. He notes that the filariids of the cotton rat, dog and man belong to different genera and that the different worms may respond differently to the same drug; but he believes that the utilization of infected cotton rats for testing the filaricidal efficiency of drugs may facilitate the discovery of a 'cure' in man.

G. F. Otto and T. H. Maren discuss the use of arsenicals in filarioid infestations. The literature and their own investigations indicate that the trivalent organic arsenicals are active in both human and canine infestations. Arsenamide kills *D. immitis* in dogs and, in well-tolerated doses, has been found to destroy the microfilariæ of *W. bancrofti*. They add: "It remains to be determined whether or not the adults of *W. bancrofti* are killed by this treatment". H. W. Brown reports on the treatment of filariid infestations with anthiomaline in the dog, cotton rat and man, and records that this compound reduced permanently the microfilariæ counts in individuals infested with *W. bancrofti*. The necessity for repeated injections, and also its toxicity, limit its usefulness, and Brown considers it only 'a stepping-stone' to be replaced by an orally administered non-toxic remedy. James T. Culbertson concludes: "*Wuchereria bancrofti* can be eradicated from many patients by the intensive administration of any of the several compounds of antimony and arsenic". He records that the pentavalent antimonial, 'Neostibosan', is well tolerated by man and has a marked destructive effect on the worms.

Twenty-five volunteers suffering from onchocerciasis were treated by F. C. Barther, T. A. Burch, D. B. Cowie, L. L. Ashburn and F. J. Brady with trivalent antimony compounds ('Stibophen' and tartar emetic). They observed no decrease in the number of microfilariæ or loss of motility in the adult worms. In one case, the administration of tartar emetic, prepared from radioactive antimony, showed that antimony had been taken up by the worm in one nodule. Harry M. Rose deals with the tolerance of antimony and arsenic compounds in intensively treated patients. The drugs used were: 'Neostibosan', 'Neostam', 'Fuadin', 'Anthiomaline' (Specia), 'Anthiomaline' (Merck), urea, stebamine, tartar emetic and stebanose.

Ernest Bueding reports that cyanine dyes in concentrations as low as one in forty millions inhibit the oxidative metabolism of *L. carinii*. The lethal action

* "The Chemotherapy of Filariasis", by various contributors. Vol. 50, art. 2. pp. 19–170 (*Ann. N.Y. Acad. Sci.*, 1948).

of cyanines in the case of *L. carinii* infestations is attributed to inhibition of the respiratory metabolism. He observes that, in contrast to vertebrates, the metabolic characteristics of invertebrates may vary greatly from species to species, and that morphologically related parasites need not necessarily be sensitive to the same chemotherapeutic agents. He rightly observes that investigations of the biochemical characteristics of pathogenic parasites may lead to the replacement of the present empirical methods by more rational methods of treatment. Lawrence Peters records that certain cyanine dyes had no chemotherapeutic effect on *W. bancrofti* although they proved lethal to *L. carinii*. He believes that this must be attributed, not to the failure of the drug to reach *W. bancrofti*, but to a difference in the metabolic characters of the two species.

S. Kushner, L. M. Brancone, Hewitt, W. L. McEwen, Y. SubbaRow, H. W. Stewart, R. J. Turner and J. J. Denton discuss the preparation of the piperazine compounds used in the search for an active filaricide which can be administered orally and is non-metallic. Hewitt, D. E. White, Kushner, W. S. Wallace, Stewart and SubbaRow report on the 'filaricidal' properties of various piperazine compounds, particularly 'Hetrazan', in dogs and cotton rats. Several of the compounds produced immediate and sharp reductions in microfilaria counts in infected cotton rats when administered orally or intraperitoneally; sometimes relapses occurred. 'Hetrazan' was also lethal to the adult worms in dogs and cotton rats. These workers record that they failed to find dead worms at autopsy in some of the treated dogs, and it seems possible that these dogs were infested not with *D. immitis* but with *D. acutiuscula*, which occur in the subcutis and have been reported from the Canadian lynx (*Lynx canadensis*). They examined only the heart and lungs for dead worms. B. K. Harned, R. W. Cunningham, Sybella Halliday, R. E. Vessey, N. N. Yuda, Mary C. Clark and SubbaRow give the structural formula of 'Hetrazan', report on its toxicity for mice, rats, guinea pigs, rabbits, cats and dogs, and cite some of its pharmacological properties.

D. Santiago-Stevenson, J. Oliver-Gonzalez and Hewitt report on the treatment with 'Hetrazan', taken by the mouth, of twenty-six individuals infected with *W. bancrofti*. The dosage varied from 0·5 mgm. to 2 mgm. per kgm. of body-weight thrice daily for periods varying from three to twenty-two days. For optimum results they suggest a dosage of 2 mgm. per kgm. body-weight thrice daily for a period of two to three weeks. There was a rapid disappearance of microfilariæ from the blood, and the development of nodular swellings at certain points of the body, usually infested by the adult worms, is accepted as proof that the compound killed some of the adult worms.

A study of "The Chemotherapy of Filariasis" will reveal that the search for a cure for filarioid infestations in man and his stock cannot be conducted behind 'iron curtains'. The workers in the various fields of science must co-operate and collaborate more and more closely than is usually the case. A better knowledge of the chemical composition and the metabolism of the various helminths parasitizing man, animals and plants may contribute materially towards the discovery of 'cures' which will not only relieve, to some degree, the present world-wide shortages of food, but will also restore normal health to many all over the world. P. L. LEROUX

# SOIL THERMODYNAMICS AND ROAD ENGINEERING

By J. D. COLEMAN

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THE movement of moisture in soil is of importance to the civil engineer owing to the effect which changes in moisture content may have on the strength and the volume of the soil. In the case of roads, both the stability and the riding qualities of the surface are involved.

The thermodynamics of the moisture contained in hygroscopic materials such as paper, tobacco and textiles has received considerable attention, and much has already been done, particularly by agricultural scientists, in applying this work to soils. A fundamental approach on these lines to the many problems associated with the transfer of moisture in road foundations is at present being made at the Road Research Laboratory.

The potential causing the migration of soil water may be regarded either as a hydraulic pressure or a vapour pressure gradient. Movements cease only when suction and vapour pressure conditions are in equilibrium with the acting gravitational field under the prevailing temperature conditions.

The curvature of each of the air/water interfaces in the soil pores is a function of the pressure change through the meniscus and of the relative humidity at the interface. The relationship between relative humidity is given to a close degree of approximation by the well-known Kelvin equation, which may be written,

$$\frac{\rho.R.\theta}{M} \cdot \log_e \frac{H}{100} = -\frac{2T}{r}. \qquad (1)$$

The actual change in pressure through the meniscus, $\rho.g.h = 2T/r$, can be expressed in terms of Schofield's $pF$ function[1],

$$pF = \log_{10} h = \log_{10} \frac{2T}{\rho.r.g}. \qquad (2)$$

Equations (1) and (2) have been used by Schofield and others in the determination of the $pF$ of soils at low moisture contents.

In the soil itself, the curvature of the air/water interfaces depends on the moisture content and on certain characteristics of the soil solids, the chief of which appears to be the particle-size distribution. It follows that the suction/moisture content and the relative humidity/moisture content relationships depend on soil type; and, in fact, the moisture contents of two dissimilar soils in moisture equilibrium may be greatly different. In road construction, where it is common on clay soils to use a stable sandy soil to form part of the road foundation, the suction/moisture content relationships are useful in estimating the equilibrium moisture (and strength) conditions.

Road foundations are subjected to both the daily and the yearly temperature cycles. It is therefore necessary to ascertain the effect of temperature on the suction and humidity relationships. The variation of the density of the soil water with temperature causes only a second-order variation in the radii of the air/water interfaces. Neglecting this variation, it follows from (2) that at two temperatures $\theta_1$ and $\theta_2$,

$$pF_{\theta_1} - pF_{\theta_2} = \log_{10} T_{\theta_1} - \log_{10} T_{\theta_2} + \log_{10} \rho_\theta - \log_{10} \rho_{\theta_1}. \qquad (3)$$

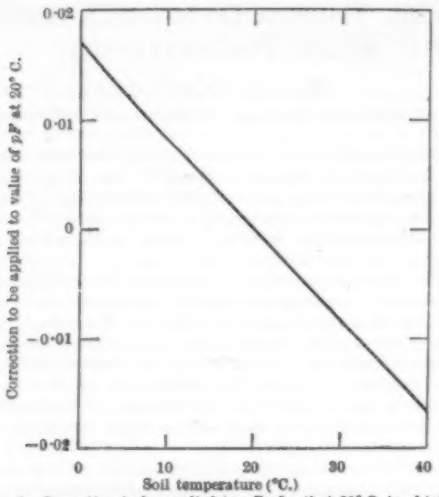


Fig. 1. Correction to be applied to $pF$ of soil at 20° C. to obtain $pF$ at other temperatures

Fig. 1, obtained from this equation, shows how small the suction difference associated with temperature gradients will be. The correspondingly small variation with temperature of the relative humidity of soil water follows from equation (1), since

$$\frac{\log_e H_{\theta_1}/100}{\log_e H_{\theta_2}/100} = \frac{T_{\theta_1}}{T_{\theta_2}} \cdot \frac{\theta_2}{\theta_1} \cdot \frac{\rho_{\theta_2}}{\rho_{\theta_1}}. \qquad (4)$$

This relationship is used to obtain Fig. 2.

The small change in relative humidity with temperature indicates that the vapour pressure of soil water varies with temperature in a manner similar to that of free water. A family of typical vapour pressure/temperature/moisture content curves is shown in Fig. 3. It follows that considerable vapour pressure gradients may be set up by comparatively small temperature differences. Further, since the relative humidity of soil water is sensibly different from 100 per cent only at moisture contents lower than those of interest to the road engineer, the following two conclusions can be reached :

(1) Differences in soil moisture content under the road will cause suction gradients virtually unaccompanied by vapour pressure gradients, and transfer will normally be in the liquid phase.

(2) Differences in temperature will cause vapour pressure gradients but not appreciable suction gradients, and transfer will normally be in the vapour phase.

Interesting confirmation of these conclusions has been obtained in this Laboratory and from practical observations. The severe drought in 1947 caused an abnormal reduction in the moisture content of road verges. Transfer of moisture in the liquid phase resulted in severe settlement and cracking on a number of roads built on heavy clays. In some parts of the world, seasonal temperature gradients are such as to cause the upward migration of water from considerable depths. Reports have been received from arid regions of California of vegetation confined solely to the verges of roads where evaporation of moisture brought to the surface was prevented by the impermeable road metal.

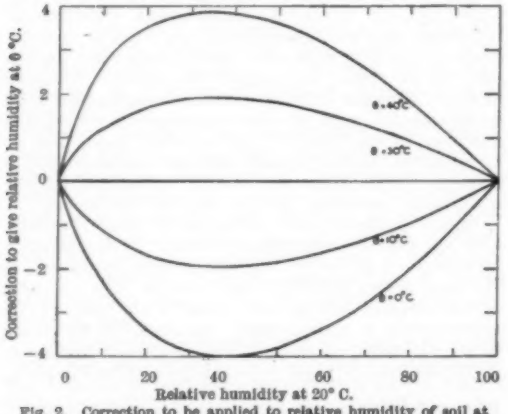


Fig. 2. Correction to be applied to relative humidity of soil at 20° C. to obtain relative humidity at other temperatures

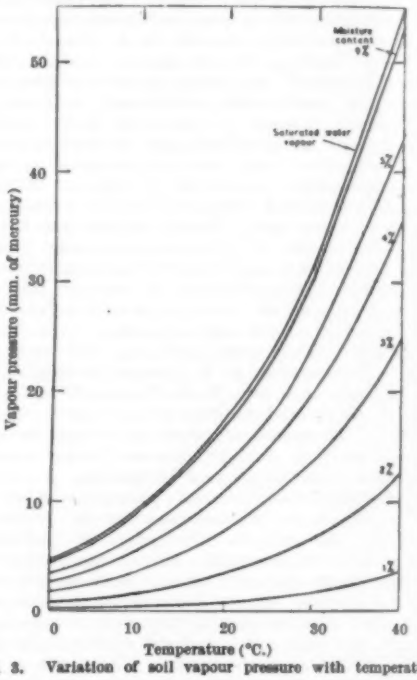


Fig. 3. Variation of soil vapour pressure with temperature

The problem of moisture transfer also involves consideration of the heat of wetting, the latent and specific heats of the soil water and the effect of temperature on each of these quantities. Detailed consideration has been given so far only to the heat of wetting. The differential heat of wetting of a hygroscopic material is obtained by Shorter[2] as

$$Q = -\frac{R\theta^2}{JM} \cdot \frac{\partial}{\partial\theta}\left[\log_e \frac{H}{100}\right]. \qquad (5)$$

Using the differential of equation (1)

$$Q = \frac{-R\theta^2}{JM} \cdot \left[\frac{1}{T} \cdot \frac{\partial T}{\partial\theta} - \frac{1}{\delta} - \frac{1}{\rho} \cdot \frac{\partial\rho}{\partial\theta}\right] \log_e \frac{H}{100}. \qquad (6)$$

Equation (6) enables the differential heat of wetting to be calculated at any given temperature. At temperatures $\theta_1$ and $\theta_2$, equations (6) and (4) give

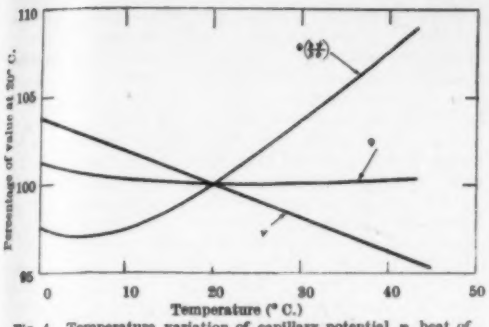


Fig. 4. Temperature variation of capillary potential, $\psi$, heat of wetting and bound energy, $\theta\,(\partial\psi/\partial\theta)$

$$Q_{\theta_1} = Q_{\theta_2}\frac{\left[\frac{1}{T_{\theta_1}}\left(\frac{\partial T}{\partial\theta}\right)_{\theta_1} - \frac{1}{\theta_1} - \frac{1}{\rho_{\theta_1}}\left(\frac{\partial\rho}{\partial\theta}\right)_{\theta_1}\right]\theta_1 \cdot T_{\theta_1}\rho_{\theta_1}}{\left[\frac{1}{T_{\theta_2}}\left(\frac{\partial T}{\partial\theta}\right)_{\theta_2} - \frac{1}{\theta_2} - \frac{1}{\rho_{\theta_2}}\left(\frac{\partial\rho}{\partial\theta}\right)_{\theta_2}\right]\theta_2 \cdot T_{\theta_2}\rho_{\theta_1}}. \quad (7)$$

Equation (5) can be written in the form

$$Q = \psi - \theta\, d\psi/d\theta,$$

where $\psi$, Buckingham's capillary potential, $-gh$, is given by

$$\psi = \frac{R.\theta}{M} \cdot \log_e \frac{H}{100}.$$

In Fig. 4 the temperature variation of $Q$ and each of its components $\psi$ and $\theta \cdot \partial\psi/\partial\theta$ is given. These curves are based on equation (7). The quantity $\partial T/\partial\theta$ was obtained from accurate surface tension data.

Further investigations are in hand, and it is hoped to publish a fuller account, including experimental results, in due course. The work is being undertaken as part of the programme of the Road Research Board, and the present note is published with the consent of the Director of Road Research.

[1] Schofield, R. K., *Trans. 3rd Inter. Cong. Soil Sci.*, **2** (1935).
[2] Shorter, S. A., *J. Tex. Inst.*, **15** (1924).
[3] Buckingham, E., U.S. Dept. Agric., Bur. Soils, Bull. No. 38 (1907).

## DEVELOPMENTS IN PICTURE TELEGRAPHY

THE transmission of pictures by land-line over various distances has been the subject of experimental development since the earliest days of telegraphic communication; and the techniques involved have been adapted similarly for transmission or relaying over radio links. Amid the excitement of other applications in recent years, such as broadcasting, radar and television, the very advanced stage which has been attained by picture or facsimile telegraphy, as the technique is termed, is apt to be overlooked. Many systems have been suggested and experimented with; but they have had a common basis in that the picture to be transmitted is placed on a revolving drum and scanned with a suitable source of light and optical system. The variations in light intensity reflected or scattered by the varying tones of the picture are converted into a fluctuating electric current through the agency of a photoelectric cell. The resulting signals are transmitted by line or radio to the receiving station, where they may be converted by a current-sensitive oscillograph into light variations which record the picture on suitable photographic paper. Alternatively, the electric currents are made to reproduce the picture by an electrochemical process. In either case, the recording paper is mounted on a drum which is maintained in rotation synchronously with that at the transmitting station.

This technique of the transmission of pictures by telegraphy is used to a large and successful extent by the Press to obtain quickly the illustrations which accompany accounts of topical events all over the world. But there are other applications in industry and the public service; and one of these, the transmission of fingerprints by radio, has been referred to in *Nature*, **158**, 525 (1946).

The name of Muirhead has been associated for more than a century with the development of instruments used in various branches of telecommunications, including in recent years the very successful production of phototelegraphic equipment. At the recent symposium held by the Scientific Instrument Manufacturers Association of Great Britain, Ltd., a paper entitled "Some Developments in Picture Telegraphy" was presented by Mr. J. Bell, of Muirhead and Co., Ltd., who have also supplied some technical literature and bulletins giving further details of the equipment. For some time now a number of the larger newspapers have operated their own picture transmission circuits comprising telephone lines linking their editorial offices with various population centres; and Muirhead–Jarvis picture-telegraph transmitting and receiving equipment is now in operation in a large number of newspaper offices in Great Britain and northern Europe. The apparatus has been designed to conform with the requirements laid down by the Comité Consultatif International Télégraphique (C.C.I.T.), and it may therefore be worked with the principal photo-telegraphic services abroad which conform to the same standards.

An amplitude-modulated form of transmission is used over wire circuits, while for radio links the principle of sub-carrier frequency-modulation is used, thereby ensuring that the signals representing the tone values of the picture are not greatly affected by fading and other disturbances of the radiofrequency carrier-wave during transmission. The picture transmission band is from 300 to 2,300 cycles per second and is thus easily within the scope of a normal telephone channel.

The standard equipment installed at the terminal fixed stations uses drum speeds of either 1 or 2 revolutions per second, and the picture is scanned at either 100 or 150 lines per inch (3·9 or 5·9 lines per mm.) for all normal requirements. Under these conditions, a picture of size 10½ in. by 10 in. (267 mm. by 254 mm.) can be transmitted in 16 min. 40 sec. and 25 min. respectively. For super-quality work, scanning at 300 lines per inch (11·8 lines per mm.) can be used, and the results obtained under these conditions are so accurate in detail as to render it difficult to distinguish the received picture from the original.

The use of normal telephone channels for the communication of news direct from the scene of the event has been followed by a demand for comparable facilities for the transmission of pictures, and the Muirhead–Belin portable transmitter has been developed to meet this demand. This equipment

consists of two suit-case units, one of which contains the power unit operating either from the electricity supply mains or from a car-starter battery. The other unit comprises the transmitter, which conforms with the C.C.I.T. requirements as regards picture size, rate of scanning, synchronizing, phasing and speed of transmission; it can therefore be used in conjunction with any make of receiver similarly standardized. As with the fixed station equipment, the speed of the revolving drum carrying the picture is maintained constant by means of a special synchronizing circuit controlled by a temperature-compensated high-stability tuning fork. The frequency of this fork is 1,020 c./s., and this is used to modulate a sub-carrier signal of 1,300 c./s., which is transmitted down the line, to provide at the receiver a synchronizing signal which is independent of any changes occurring in the telephone carrier-signal.

There is also available a portable dark-room, comprising a small tent and full photographic facilities, and this is fitted up in two suit-cases for use with the portable picture transmitter. This equipment allows the processing of pictures to be carried out quickly and conveniently in any location.

The bulletins referred to above contain several photographic reproductions in support of the claim that "Muirhead machines are producing the best wired pictures in the world".

## ANCIENT ARTS AND MODERN PARODIES

THE exhibition entitled "40,000 Years of Modern Art", which opened at the Academy Hall in Oxford Street, London, just before Christmas and closes at 10 p.m. on January 29, makes no claim to a scientific approach—to which, indeed, so cavalier a title would have been rather ill attuned—yet it possesses surpassing interest for anthropologists, and may well do a good service to science by inducing them, and other visitors, to look at primitive art in new ways under the shock of the juxtaposition with a sufficiently aggressive selection of modern paintings and sculptures. The Institute of Contemporary Arts, 6 Fitzroy Street, London, W.1, a recently formed body devoted to the good cause of encouraging new trends in all the arts (but the approach of which is perhaps not yet quite so wide as its scope), is to be warmly congratulated and thanked for assembling what is almost certainly the most impressive display of primitive art ever held in Great Britain outside the great ethnographical museums.

The selection, though partly conditioned by the desire to find parallels for the moderns, has not suffered unduly thereby, and there are only a few pieces (such as a dubious Easter Island figure) which seem to have been included less for their merit than their surrealism. Many, if not most, of the Oceanic and (especially) African pieces are of the very first class within their types; some cannot be paralleled here at all. The Pitt Rivers and Ashmolean Museums at Oxford, the Horniman Museum and the Brighton Museum have all made notable contributions, and the magnificent private collections of Mr. Webster Plass and Mr. W. O. Oldman have been drawn upon to excellent effect. Among the finest pieces are the most forceful of all Basonge masks (Belgian Congo), owned by Mr. R. Penrose; Mr. Plass' bust of a Baga fertility divinity (French Guinea); the Northern Yoruba earth goddess from the Horniman Museum; two large fetish figures of the eastern and western Belgian Congo from the Oldman collection; some fine reproductions from the Frobenius Institute at Frankfurt of Australian and African rock paintings; and an outstanding series of polychrome *malanggan* carvings from the New Ireland collection at Brighton. The word 'primitive' has been rather strictly interpreted, to exclude the barbaric 'civilizations' of West Africa, Indonesia and pre-Columbian America, and this has meant that certain forms of sculpture pre-eminently appropriate to this exhibition (such as the more mystical of the Benin bronzes) are unrepresented. Less easy to explain is the truly primitive sculpture of Borneo and other parts of the East Indies.

The declared purpose of the exhibition is to compare primitive and modern and to suggest a community of inspiration between them. But one's main impression on leaving the show (and this is confirmed by most of the art critics) is rather of antithesis. It is true that there are superficial resemblances of form (though many of those to which the organisers direct attention are, in fact, purely fortuitous); but fundamentally they are opposed in conception and function. Primitive art is everywhere (even in medieval Europe) an art of conformity, of devoted acceptance in both a spiritual and a material sense; the forms develop over hundreds, or even thousands, of years, by processes which are essentially evolutionary, and have a four-dimensional quality about them which arises from their conception not by a single artist, but by many generations of artists, not as an escape, but as at once the expression and the support of the social pattern. 'Modern' art, on the contrary, is to a large extent frankly revolutionary, and, moreover, is still, after forty years, in the destructive phase of anarchism, comparatively few artists having begun, like Henry Moore (who almost alone in this exhibition seems to hold his own with the peoples of Nature), to build the foundations of a new order amid the chaos; too many of them are iconoclasts, content to satirize our world by drawing, for their purely intellectual inspiration, upon the form but not the content of the deeply religious art of the primitive peoples (with the same cynicism with which an atheistic totalitarianism will tolerate or even sponsor a subservient form of Christianity for its own ends). In this deeper sense, then, primitive art is actually nearer in spirit to the traditionalism of the Royal Academy than to the exuberance of its own imitators. Sincerity, it may be thought, is the most flattering form of imitation.

We may be all the more grateful to the Institute of Contemporary Arts for putting the moral so clearly before us that there is a virtual unanimity among both critics and members of the public. The Institute has thus laid a fine foundation for its future work, and we may look to it with confidence and hope for the constructive leadership which will not only give direction and stability to modern art in the post-Picasso era, but also make its contribution to a re-integration of the cultural elements in our schizophrenic society.

Two further words should be said: the arrangement of the exhibition, though bold and imaginative, strains perhaps a little too self-consciously after the sales technique of a show of industrial design, instead of the self-effacement proper to the display of works

of art; and the catalogue (though not wholly innocent of the same tendency) contains an essay by W. G. Archer and Robert Melville which is a valuable stimulant to thought about primitive and modern art and their interrelations, and in which both artists and ethnologists may find not a few provocative sentences. We may hope that the collaboration between art and science will be pushed much further.

WILLIAM FAGG

## SECULAR CHANGES IN THE EARTH'S MAGNETIC FIELD

DR. E. C. BULLARD has described (*Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., **5**, No. 7, July 1948) the rapid changes in the earth's magnetic field in South Africa, from which certain tentative conclusions are drawn. From data in tables 25, 29 and 33 in "Descriptions of the Earth's Main Magnetic Field and its Secular Changes", by E. H. Vestine and others (Carnegie Institution, Washington, 1947), a diagram is constructed showing the annual changes in the horizontal and vertical fields in South Africa at 1922·5; this date has been chosen because it is believed that the secular variations are better known then than at any other time.

From detailed calculations it seems possible that motions in the liquid core of the earth can partly explain the rapidity of change, though, as shown in the calculations, it is difficult to obtain a sufficient field by these means. Some of this difficulty, it is hoped, may be removed by a more thorough analysis of the secular change. The movement of the material of the earth's core through the general magnetic field of the earth could induce electric currents which produce the secular changes in the magnetic field, and the world-wide part of the change may be due to motions some thousands of kilometres in diameter. From 1843 to 1900 the change at Cape Town was comparatively small (0·02 gauss in all) and may not have been due to a local eddy.

No explanation is given regarding the causes of the motions in the liquid core, but it is suggested that radioactive generation of heat there might produce thermal convective currents. A similar effect would result from asymmetry in the earth's cooling, and another possibility is that the slipping of the outer part of the earth over the core, while the earth's rotation slows down by tidal friction, may have had some effect.

A full investigation of the theory proposed would be a tedious matter, and it is not suggested that it is complete at present, but it is hoped that it will "stimulate modifications that will agree more exactly with the very complicated facts".

## RUBBER INDUSTRY IN GERMANY

THE B.I.O.S. Overall Report No. 7 on "The Rubber Industry in Germany during the Period 1939–1945" has recently been published (London: H.M. Stationery Office, 1948. 2*s.* 6*d.* net). This comprehensive report will be primarily the concern of the rubber technologist, but there are a number of aspects which will interest all scientific workers in the high-polymer field. Perhaps the most interesting is the heat sensitization of latex by the use of polyvinyl ether ('Igevin M50'), because the process depends upon the curious fact that this material is soluble in latex or water at room temperatures, but becomes insoluble at 35° C., and causes the rubber to coagulate as it separates out. 'Igevin M50' is used in 3–7 per cent concentration referred to the rubber content, and the mixed solution is indefinitely stable at 25° C., thus contrasting markedly with other heat-sensitizing materials.

The German synthetic rubber industry started long before the American industry, and it has been of interest to note that, in each case, the bulk of the synthetic rubber produced was of the butadiene–styrene type, with butadiene–acrylonitrile polymers running second. What has not been generally realized, however, is that the Germans also had a large number of varieties, not only of the butadiene–styrene type, but also of other types, and these are described on pages 22–30 of the report. Two promising polymers of which little has previously been heard are 'Buna K', a copolymer of butadiene and methyl vinyl ketone, and 'Buna M', where butadiene was polymerized with methyl methacrylate.

Another synthetic rubber which seems to show remarkable promise is 'Vulkollan N'. This is an ester-type rubber, prepared from polyethylene adipate and naphthalene di-*iso*cyanate, which it is claimed will render all other polyester rubbers obsolete, being non-hardening, of high tear-resistance, and having lower hysteresis. Its resistance to abrasion is said to be ten times that of natural rubber, the tear-resistance is 53 per cent higher, and the solvent resistance is equal to that of 'Perbunan'; it will be interesting to see whether the manufacture of this rubber can be made a commercial proposition.

In the field of testing, the Germans were actively aware of the prime importance of laboratory tests for the 'processability' of their polymers, and they developed many tests which will be of interest to those technologists who had to struggle with the intractable rubbers which were the early product of the American industry. Other subjects of particular interest to technologists are the new non-black reinforcing fillers 'Tonerdegel' and 'White Carbon', the account of abrasion machines, and the discussion of thermal plasticization.

R. G. NEWTON

## FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

### Monday, January 24

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Dr. P. Johnson: "The Ultracentrifuge and Electrophoresis Apparatus in Protein Research".* (Further Lectures on January 31, February 7 and February 14.)

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5 p.m.—Prof. C. G. Rossby: "Air Mass Meteorology—its Geographical Implications".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Generation of Electricity by Gas Turbine Plant".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Symposium on "Juvenile Delinquency".*

TEXTILE INSTITUTE, YORKSHIRE SECTION (at Alexandra Café, King Edward Street, Halifax), at 7.30 p.m.—Mr. F. L. Goodall: "The Battle against Textile Pests".

CHEMICAL SOCIETY, OXFORD SECTION (in the Physical Chemistry Laboratory, Oxford), at 8.15 p.m.—Prof. N. V. Sidgwick, F.R.S.: "Some Remarks on the Periodic Table" (Alembic Club Lecture).

### Tuesday, January 25

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 10 a.m. and 2 p.m.—Conference on "Combined Heat and Power Supplies".*

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Dr. Ian Hogbin: "Social Status in Melanesia".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Prof. L. S. Penrose: "The Work of the Galton Laboratory".*

INSTITUTION OF ELECTRICAL ENGINEERS, SOUTH MIDLAND CENTRE (at the Town Hall, Birmingham), at 6 p.m.—Sir Noel Ashbridge and Mr. H. Bishop: "Television" (Faraday Lecture). (To be repeated on Wednesday, February 2, at the Philharmonic Hall, Hope Street, Liverpool, at 6.45 p.m.: on Wednesday, February 9, at the Houldsworth Hall, 90 Deansgate, Manchester, at 7.30 p.m.: on Wednesday, February 16, at Central Hall, Westminster, London, S.W.1, at 6.30 p.m.: on Wednesday, March 16, at the De Montfort Hall, Leicester, at 7.15 p.m.: on Wednesday, March 23, at the City Hall, Sheffield, at 7 p.m.: on Tuesday, March 29, at the City Hall, Newcastle-upon-Tyne, at 7 p.m.: and on Tuesday, April 5, at the Central Hall, Tollcross, Edinburgh, at 7 p.m.)

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND S.E. COUNTIES SECTION (at High Duty Alloys, Ltd., Buckingham Avenue, Trading Estate, Slough), at 6 p.m.—Prof. H. V. A. Briscoe: "The Chemistry of Dusts".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (in the Chemistry Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 6 p.m.—Discussion on "Rheological Methods of Control".

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. J. Arnold Berry: "Three Indian Cities—Bombay, Agra and Delhi".

## Wednesday, January 26

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. Thomas Swarbrick: "The Application of Science to Fruit Growing".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting: Dr. G. M. B. Dobson, F.R.S.: "Ice in the Atmosphere".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (joint meeting with the ACOUSTICS GROUP of the PHYSICAL SOCIETY, at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. E. M. Payne: "The Development of Magnetic-Tape Recorders".

LINNEAN SOCIETY OF LONDON (in conjunction with the SYSTEMATICS ASSOCIATION, at Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. A. J. Wilmott: "Botanical Taxonomy from Linnæus to Darwin".

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, CHEMICAL SECTION (at the Portico Library, 57 Mosley Street, Manchester), at 5.30 p.m.—Mr. H. Stevenson: "Long Term Policy in Chemical Industry, especially in Textiles".

INSTITUTE OF WELDING (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Sir William J. Larke Medal Paper.

BRITISH ASSOCIATION OF CHEMISTS (in the small Conway Hall, Red Lion Square, London, W.C.1), at 7 p.m.—Mr. F. A. Robinson: "Antibiotics".

TELEVISION SOCIETY (at the C.E.A., 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. M. Morgan: "Television Transmission and Reception at 480 Mc./s.".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "Research Teams" (to be opened by Sir George Thomson, F.R.S., Sir Charles Harington, F.R.S., and Dr. H. O. Wansbrough-Jones).

## Thursday, January 27

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. B. S. Haldane, F.R.S.: "Some Modern Views on Evolution".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Royal Greenwich Observatory".

MINERALOGICAL SOCIETY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. H. W. Thompson, F.R.S.: "Infra-Red Measurements in Physics, Chemistry and Biology". (Further Lectures on February 3, February 10 and February 17.)

ROYAL AERONAUTICAL SOCIETY (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 6 p.m.—Dr. F. E. Jones: "Radar as an Aid to the Study of the Atmosphere".

## Friday, January 28

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (at the College of Technology, Manchester), at 2.30 p.m.—Annual General Meeting: Dr. F. A. Freeth, F.R.S.: "The Place of Heterogeneous Equilibrium in Chemical Engineering".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion.

CHEMICAL SOCIETY, SOUTHAMPTON SECTION (joint meeting with the CHEMICAL SOCIETY of University College, Southampton, in the Physics Department, University College, Southampton), at 5 p.m.—Dr. R. P. Linstead, F.R.S.: "Some Aspects of Recent Work at the Chemical Research Laboratory, Teddington".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. F. Bergel: "Some Aspects of Pharmacological Chemistry".* (Further Lectures on February 4 and February 11.)

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Discussion on "Fluid Mixing by Jets and Cyclone Dust Collectors".

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. H. G. Yates: "Vibration Diagnosis in Marine Geared Turbines".

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (at the Society of Architects, 16 St. Mary's Parsonage, Manchester), at 6.45 p.m.—Dr. G. P. Sillitto: "The Design of some simple Physico-Chemical Experiments".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS, to teach up to B.Sc. General Degree standard—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham (January 29).

SENIOR BIOCHEMIST or BIOCHEMIST—The House Governor, Royal Free Hospital, Gray's Inn Road, London, W.C.1 (January 31).

READERSHIP IN OLD JAVANESE at the School of Oriental and African Studies—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

PHYSICISTS and ELECTRICAL ENGINEERS (unestablished, Senior Scientific Officer and Scientific Officer grades) at the Royal Aircraft Establishment, Farnborough, and other Ministry of Supply establishments in southern England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.436/48A (February 5).

LECTURER IN METALLURGY in the Department of Applied Chemistry—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1 (February 12).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Sheffield (February 19)

LECTURER IN ENGINEERING with special interest in strength of materials and structures—The Secretary, The University, Aberdeen (February 21).

SENIOR LECTURER or LECTURER IN PHYSIOLOGY in the University College of the West Indies—The Secretary, Senate Committee on Higher Education in the Colonies, University of London, Senate House, London, W.C.1 (March 1).

CHAIR OF ANTHROPOLOGY at Auckland University College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 32 Woburn Square, London, W.C.1 (March 1).

READERSHIP IN INDIAN PHILOSOPHY at the School of Oriental and African Studies—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 28).

DIRECTOR OF THE RUBBER RESEARCH SCHEME of Ceylon—The Chairman, London Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, South Kensington, London, S.W.7 (March 31).

DIRECTOR OF THE INSTITUTE OF SOCIAL AND ECONOMIC RESEARCH, University College, Ibadan, Nigeria—The Under-Secretary of State, Research Department, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1 (March 31).

TECHNICAL ASSISTANT IN ELECTRONICS—Dr. B. Bowden, Caius College, Cambridge.

LECTURER IN MECHANICAL ENGINEERING—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

SOCIAL ANTHROPOLOGIST, for a study of the Ndebele of Southern Rhodesia—The Director, Rhodes-Livingstone Institute, P.O. Box 195, Livingstone, Northern Rhodesia.

RESEARCH ASSISTANT FOR BIOCHEMICAL LABORATORIES—The Secretary, Institute of Psychiatry (University of London), Maudsley Hospital, Denmark Hill, London, S.E.5.

SENIOR ENTOMOLOGIST, and FIELD ENTOMOLOGISTS (3), in the East Africa Desert Locust Survey—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

PHYSICAL CHEMISTS (Scientific Officer grade) at a Ministry of Supply Research and Development Establishment near London, for work in (*a*) high temperature refractories, (*b*) crystallography and practical microscopy, (*c*) spectrography, and (*d*) plant development—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting F.1025/48A.

MECHANICAL ENGINEER to take charge of a department of research on flax production—The Director, Linen Industry Research Association, Lambeg, Belfast.

AGRICULTURAL CHEMIST in the Department of Agriculture, Sierra Leone—The Director of Recruitment, Colonial Service, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Higher Education for the People. By Christopher Meredith. Pp. viii+88. (London: Communist Party, 1948.) 3*s.* 6*d.* [140

Transactions of the Royal Society of Edinburgh. Vol. 61, Part 3, No. 22: The Genus Primula; Sections Cuneifolio, Floribundae, Parryi and Auricula. By Sir W. Wright Smith and Dr. H. R. Fletcher. Pp. 631–686. (Edinburgh and London: Oliver and Boyd, 1948.) 14*s.* [140

Haven Products: a Scottish Experiment in the Employment of Severely Disabled Men. By A. E. Turner, T. A. Stirrat and F. Ferguson. Pp. iv+27. (London and Edinburgh: Nuffield Provincial Hospitals Trust, 1948.) [140